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Significant Foraminifera in the Austin Group.

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SIGNIFICANT FORAMINIFERA IN THE AUSTIN GROUP

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ABSTRACT

This dissertation presents the results of a study of the relationship of the foraminiferal fauna to the stratigraphy of the Austin group. Approximately three hundred samples were collected from exposures between San Antonio and Waco, Texas from which the data have been assembled.

Selected species of Foraminifera are presented on a range chart to illustrate their succession in the "Type" area near Austin, Texas. Of these, Citharina texana (Cushman) is shown to be present in all but the lowest portion of the Austin group and to be absent from younger beds. Kyphopyxa christneri (Carsey) is shown to evolve from Palmula suturalis (Cushman) in the middle chalk member of the Lower Austin and to characterize all younger beds in the group. A faunule characterized by Flabellammina clava Alexander & Smith and Haplophragmium taylorense Cushman & Waters is shown to be present at, and limited to, several horixons within the Austin.

It is further shown that Planulina taylorensis (Carsey) is controlled by facies since it is found only in sections composed entirely of clay; whereas Citharina texana (Cushman) is controlled by time since it is present in beds assignable to the Austin group regardless of lithology.

These data are plotted on the stratigraphic grid previously established by Durham in order that the correspondence between the foraminiferal fauna and the stratigraphy can be discerned readily.

The various environments of deposition involved in the Austin sedimentation are interpreted by the fauna as ranging from littoral to deeper water off-shore and in a single instance to possible euxinic conditions.

An appendix containing maps and sections of the localities from which collections were made and the stratigraphic position of each sample and its faunal content is included in the dissertation.

INTRODUCTION

In central Texas near the city of Austin the Austin group is recognized as a 400 foot thick sequence of chalk beds intercalated with thin clay marl layers. The lower portion of the Austin group is considered Coniacian in age by Bose (1927, p. 171) and is underlain by the dark shale of the Eagle Ford of Turonian age. The upper Austin is determined as lower Santonian age and is overlain by the Taylor marl, of upper Santonian age (Bose, 1927, p. 172).

In his doctoral dissertation, Durham (1957) presents a detailed stratigraphic correlation of beds assigned to the Austin group between San Antonio and Waco, Texas. His interpretation is based on a bed-by-bed correlation from one exposure to the next by means of carefully drawn stratigraphic sections. The results have been assembled to form a stratigraphic grid upon which changes within the area studied can be readily recognized.

The present paper is an attempt to establish the relationship, if any, between the foraminiferal fauna of the Austin and its stratigraphy as described by Durham; and to select from among the species present any which may have a particular significance within the Austin group. It is not considered within the scope of this investigation to attempt any additions or corrections to the systematics involved and for this reason only standard names and the most clear-cut species have been considered.

PREVIOUS WORK

Early work on the Austin group dates from 1852 when Roemer investigated the sections at "Wasserfal de Guadeloupe" near New Braunfels and along Cibolo Creek about fifteen miles farther south; both these sections are used in the present work. The name Austin was not applied to these strata until 1860 when Shumard (1860 p. 585) reworked Roemer's localities and also recognized the same lithology at Austin and as far north as Grayson County. Thirty-two years later Taff (1892, pp. 350-4) attempted the first stratigraphic subdivision of the Austin and designated four lithic units: chalky limestone at the bottom, arenaceous horizon, "aucella" horizon (named for Gryphea aucella Roemer), and marly lime zone at the top. Four divisions were recognized by Adkins (1933, p. 449): lower chalk, middle marl, and upper chalk for the typical Austin and an uppermost unit of chalk-marl which he named Burditt.

There followed a period of paleontological investigation during which Stephenson (1937, p. 132) established five traceable faunal zones in the middle and upper Austin of Central Texas. Young and Marks (1952, p. 479) duplicated only one of Stephenson's zones, the Inoceramus undulatoplicatus zone, in describing six faunal zones within the entire Austin in Williamson County. McNulty (1955) described the foraminiferal fauna of the Austin in the Dallas area from the first systematic collection of material ever attempted from these beds. In addition to describing sys-

tematically one hundred forty-eight species of Foraminifera, of which eleven are new and eight possibly new, he charted the range of each species and pointed out the difference between the fauna of the "middle marl" and that of the "upper chalk" and also the similarity of the fauna of the Gober chalk with that of the lower beds of the Taylor group, all in the Dallas area. An investigation of the Ostracoda of the Austin in Northeast Texas has been concluded by Paulson (1959).

The most recent work on the stratigraphy of the Austin is that of Durham (1957). Working between San Antonio and Waco he considered the Austin divisible into two major parts and these divisible as follows: the lower into his Atco formation at the base, the Vinson chalk south of Austin interfingering with the Bruceville marl north of that city, and the Jonah limestone south of Austin which thickens and interfingers into a chalk northward. These correspond respectively to the lower chalk, middle marl, and upper chalk of the Dallas area described by Schuler in 1918; the upper portion has been divided by Durham into the Dessau formation at the base with a lower member, the Schwertner, the Burditt chalk-marl, and an uppermost chalk which he has called the Big House.

FIELD WORK

During the Summer of 1955 over two hundred fifty samples of Austin material were collected from some twenty-five sections along strike from Cibolo Creek north of San Antonio to White Rock Creek north of Waco. Additional collections were made in May 1960 in company with Durham in order to fill in certain important voids which had shown up as the foraminiferal markers were discovered.

In order that coverage in all areas should be as complete as possible the sections collected were selected by Durham as the most representative from among those used in his stratigraphic study. In this way the samples were tied directly into his stratigraphic units in order that any foraminiferal markers or changes could be identified with his divisions. The results thus obtained could be expected to agree or disagree, in part or entirely, with Durham's stratigraphy.

Collection method

Since it has been well established that the chalky portions of the Austin are not only difficult to wash but contain little foraminiferal material, only the marl breaks between chalk beds were sampled. An additional advantage of such collecting is that possible variation due to facies change is largely eliminated and therefore such faunal changes as might develop could be thought due more to evolution than environment.

With Durham's sections at hand it was possible to

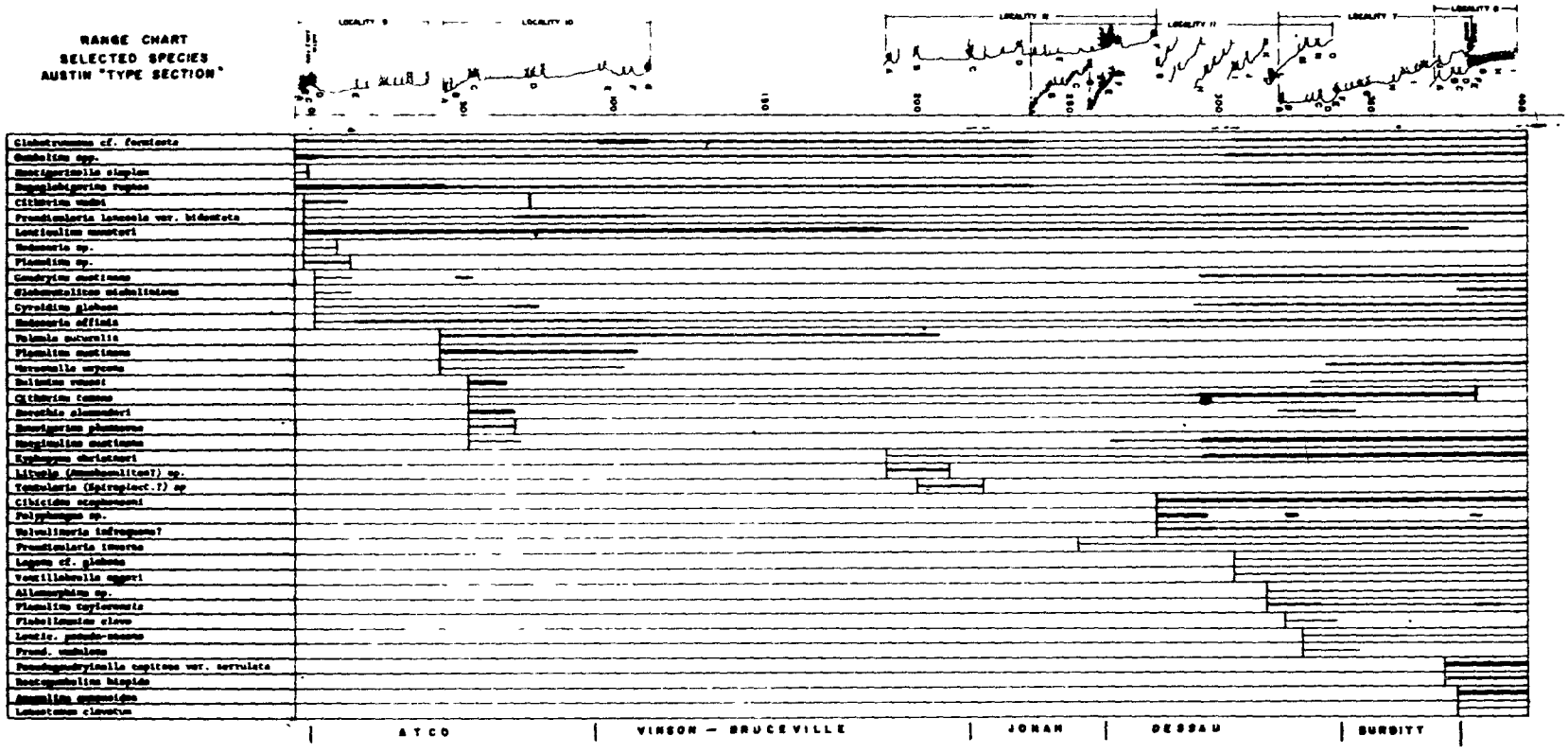
RANGE CHART
SELECTED SPECIES
AUSTIN "TYPE SECTION"
LOCALITY 9
LOCALITY 10
LOCALITY 12
LOCALITY 11
LOCALITY 7
LOCALITY 6
Globotruncana cf. fornicata
Gumbelina spp.
Heterohelix simplex
Hoeglundina rugosa
Citharina undet
Frondicularia lanceola var. bidentata
Lenticulina muensteri
Nodosaria sp.
Planulina sp.
Gaudryina austinana
Globorotalites michelinianus
Cyroidina globosa
Nodosaria affinis
Valvulo cuturalis
Planulina austinana
Verneuilina arpeana
Bulimina vulgata
Citharina tenuis
Heterhelix alexanderi
Heterolepa planulata
Marginulina austinana
Epphopyxa christneri
Bitubulo (Dorothia?) sp.
Textularia (Spiroplect.?) sp
Cibicides stephensoni
Polyphragma sp.
Valvulineria infrequens?
Frondicularia inornata
Lagena cf. globosa
Vaginulinopsis ogeri
Allomorphina sp.
Planulina taylorensis
Flabellammina clavo
Lenticulina gaudo-mesana
Frond. umbilena
Pseudoglandrulina capitosa var. serrulata
Neoeponides bilpida
Anomalina argenteida
Lenticulina clavatus
ATCO
VINSON — BRUCEVILLE
JONAH
DESSAU
BURDITT

Figure 1

identify his beds from the sketched weathering pattern of each exposure and on these the position of each sample was plotted.

LABORATORY METHODS

Sample preparation

One hundred grams of each sample was weighed, boiled in a sodium carbonate solution, and washed through a two hundred mesh screen in a "Jet-O-Matic" sample washer, manufactured by the W. H. Curtin Company. This operation was repeated, with drying between each washing, an average of three times in order to obtain material as clean as possible. There is sufficient calcareous material in the marls to make them difficult to wash and it is only by these repeated efforts that a comparatively clean sample could be obtained.

Identification of fauna

The identifications of Foraminifera in this work are based on Cushman (1946), Frizell (1954), and McNulty (1955) and are therefore those in standard usage. Only those species which could be identified with reasonable certainty from these publications are presented in the range chart and faunal lists.

Presentation

The range chart (Fig. 1.) of species from the "Type" area of the Austin group was prepared to illustrate the development of the fauna from the Eagle Ford contact at the bottom to the Taylor contact at the top. This chart presents Durham's original sections against which the foraminiferal species have been plotted in groups based on earliest occurrence. The genera of each group are arranged in alphabetical order for convenience.

By recording the fauna of each sample of the collection, various lines of possible correlation became apparent and certain of these were observed to hold regular relationship to one another. These more stable markers have been selected for presentation against the background of Durham's stratigraphic grid (Fig. 2). Each section collected is represented by a vertical line on the grid in its proper geographic and stratigraphic position, checked by Durham for agreement with his work. By this method the completeness of the coverage in any area is readily apparent and the stratigraphic position of each fossil can be established accurately. Thus any similarity or discrepancy between fossils and stratigraphy is immediately revealed.

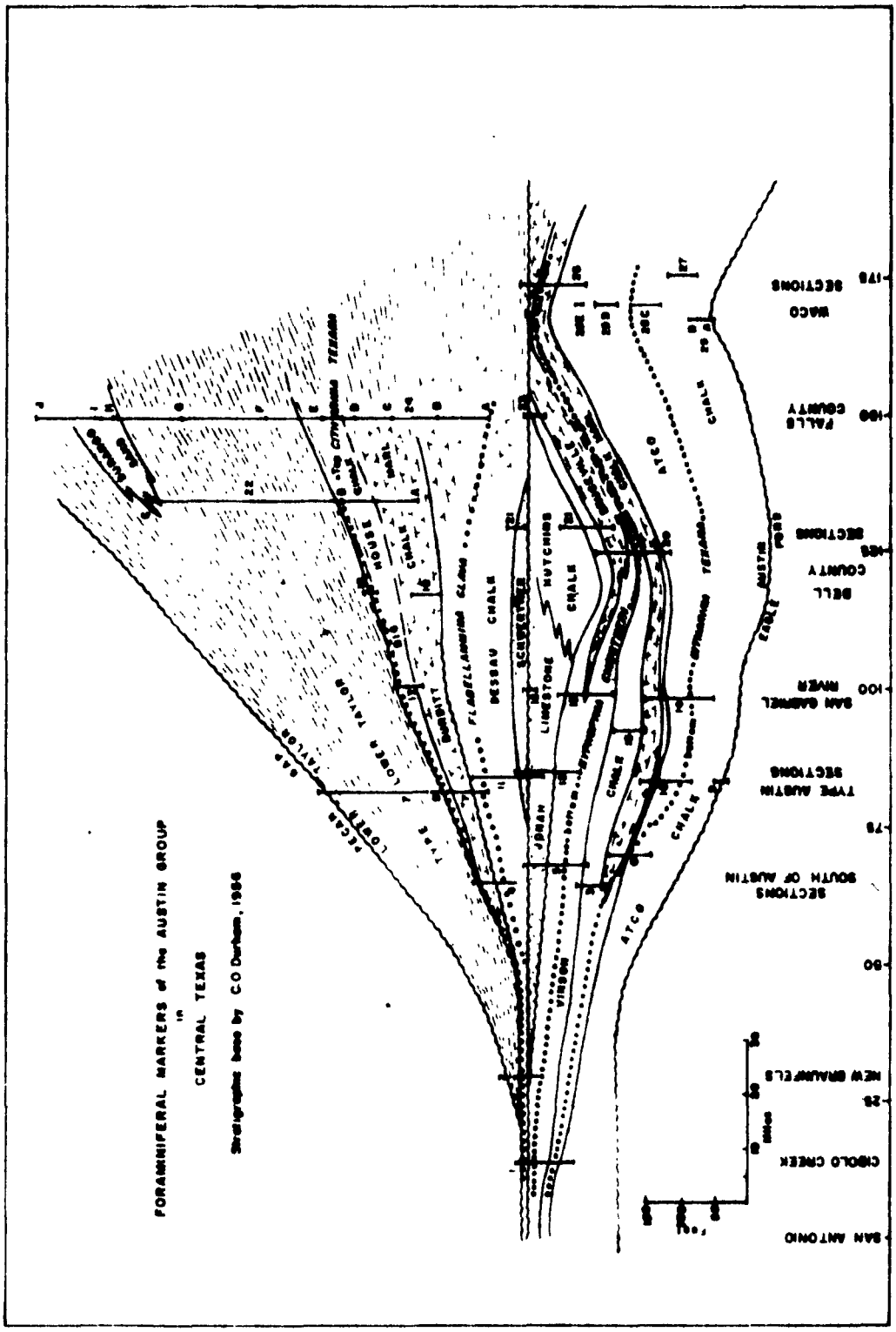
FORAMINIFERAL MARKERS of the AUSTIN GROUP
in
CENTRAL TEXAS
Stratigraphic base by C.O. Durham, 1956
SAN ANTONIO
CIBOLO CREEK
NEW BRAUNFELS
SOUTH OF AUSTIN SECTIONS
TYPE AUSTIN SECTIONS
SAN GABRIEL RIVER
BELL COUNTY
PALLS COUNTY
BRAZOS SECTIONS
ATCO
CRETACEOUS
TERTIARY
EAGLE FORD
AUSTIN
BUDA
DEXAU CHALK
LIMESTONE
HUTCHINS
CHALK
MARL
SHALE
SAND
CLAY
LOWER TAYLOR
UPPER TAYLOR
NAVARRO
TEXAS
CLAIBORNE

Figure 2

ENVIRONMENTS

Lithologies within the Austin vary considerably and are similar only in that there is always a high percentage of lime present. These different lithologies are believed to indicate different depositional environments but the similarity of composition is sufficient to indicate that no great changes should be expected. From the particularly even-bedded nature of the entire group it can be inferred that quiet shallow-water conditions prevailed, but facies changes indicate that there was gradation from littoral to moderate depth conditions northward from the San Marcos platform.

The several environments will be discussed under the various indicative lithologies: calcarenite and fragmental limestone for littoral environment; glauconite, localized at levels of disconformity, indicating interrupted sedimentation; chalk for off-shore environment of continual deposition considered typical of the Austin group; and clay or marl representing continual deposition in deeper water off the San Marcos platform considered atypical but contemporaneous with other Austin sediments.

Calcarenite

Southward from Austin toward the San Marcos platform the Austin sequence becomes increasingly grainy and fragmental. This is accompanied by an increase in the amount of secondary calcite present as interstitial grains readily observable in washed samples from localities in this area. Although marl breaks are present in this area they are neither so well

developed nor so marly as those north of Austin and the material can be washed only with great difficulty. This is considered to indicate a shallowing of the sea onto the platform. Durham (1957) believes that this shallowing becomes so marked as to permit subaerial conditions to exist from time to time. He offers the truncation of beds and the prominence of the disconformities southward from Austin as substantiating proof of this. It is here noted that Foraminifera are much less numerous in these coarse sediments than in the finer grained material north of Austin. This scarcity probably results from leaching in these more permeable coarse deposits. However, it is likely that some of the species of the deeper water environment of the northern sections could not live in the shelf shallows and perhaps some of the others were not so abundant here as elsewhere.

Glauconite

An indication of local or temporary conditions of retarded deposition is the presence of large amounts of the mineral glauconite at certain levels. This is particularly true of the lower portion of the Schwertner lying between two discontinuities near the base of the Dessau formation. These few feet of section contain more of this mineral than is to be found in any other part of the Austin group. Although glauconite is known not to be associated with subaerial conditions its presence in sediments does not indicate that such conditions did not exist. Very likely some subaerial erosion took place at some, if not all, of

the disconformities in the Austin and the glauconite present at these levels may represent part of the sediment of the subsequent transgression.

Chalk

Chalky limestone is the dominant lithology within the Austin group. It is considered that the chalks were deposited continuously in deeper water off shore beyond the extent of transport of fragmental material from the San Marcos. platform. The massive chalks are intercalated at irregular intervals with thin marl breaks similar to the clays deposited synchronously to the north. Since all the clays are essentially similar and since the chalks are all alike, the alternation is thought to be due to an influx of clay rather than to a change in depositional environment. Under such conditions the excess of clay merely masks the continuously depositing chalk.

Foraminifera are rarer in the chalks than in the marl breaks of the Austin sequence. This might be thought to indicate changing conditions but it is not so taken here; rather it is believed that the fauna was the same throughout but has been preserved by the impermeable nature of the clay and leached in the more permeable chalk.

Clay

Only north from Austin, particularly in the Dessau formation and Burditt chalk-marl, does clay become the dominant material of the sediments. This is considered the area of deeper water environment (Durham, 1957) and therefore the

area of most continuously consistent clay deposition. It is in these beds that some Foraminifera, associated only with the Taylor group farther south, appear at progressively lower horizons and thus indicate their close relationship with environment. If Durham's contention is correct that the lower portion of the thick clay deposits in the Waco area is equivalent to the thinner chalk section (Dessau, Burditt, and Big House) near Austin, it can be deduced that the environment of excessive and continuous clay deposition controlled this early development of the Taylor forms. Citharina texana (Cushman) does not occur in beds above the uppermost Austin at the type locality. Therefore its presence in the lower three hundred feet of clay at Waco is taken as evidence that these clays correlate with the upper chalks and marls at the type locality near Austin, Texas.

DISCUSSION OF FAUNAS

The foraminiferal fauna of the Austin group is distinctly different from that of the underlying Eagle Ford. The boundary between the two lithic units is a well recognized disconformity and represents a change from the dark shale (euxinic?) conditions of the Eagle Ford to the more aerated conditions of Austin deposition. Eagle Ford material was collected at Austin and Waco, where the contact was exposed, and the fauna was found to consist almost entirely of pelagic forms. Immediately above the contact the Austin contains a more diversified fauna of benthonic nature.

As suggested by Cushman (1946, p. 78) and others, Citharina texana (Cushman) is shown by the present study to have a stratigraphic range limited to the Austin and extending throughout the group except for the lowermost one hundred thirty feet (more or less) of the Atco chalk. Other species, mentioned below, also are significant in the Austin group though not limited to it. Kyphopyxa christneri (Carsey) makes its earliest appearance in the Vinson - Bruceville sequence. Haplophragmium taylorense Cushman & Waters and Flabellammina clava Alexander & Smith are present at several levels which may be horizons of change in rate or type of deposition. Planulina taylorensis (Carsey)[1]

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[1]The proper name for Planulina taylorensis (Carsey) is Planulina dumblei (Applin) but since the name Planulina taylorensis is well established in the literature it is the designation used in this paper (Applin, 1925, p. 87).

its earliest appearance in the upper portion of the Austin group and, as will be shown later, gives evidence of being controlled by facies because of its association only with clay sediments. Other species more characteristic of Taylor beds, Anemalina ammonoides (Reuss) and Valvulineria infrequens Morrow, also have their earliest occurrences in strata of the upper Austin group.

Cushman (1946) lists one hundred forty-three species of Foraminifera from the Austin group of Texas. McNulty (1955) described an additional eleven new species and eight possibly new ones and charted the range of the one hundred forty-one species he identified from his collections. The range chart (Fig. 1) in the present paper contains only the thirty-nine species which are most consistently present in the area under investigation. Under the heading of each of Durham's stratigraphic units are listed the species which make their earliest appearance within it. Since each species persists above its introduction into the fauna, the list is cumulative.

The earliest foraminiferal fauna of the Austin can be considered the beginning of the varied fauna of the upper Cretaceous from which some six hundred foraminiferal species have been described.

Atco

The lowermost beds of the Atco formation show a marked difference in fauna from the underlying Eagle Ford. The earlier beds contain an almost entirely pelagic fauna whereas the Austin beds contain large numbers of benthonic

foraminifers. The most conspicuous single element in this fauna is the large numbers of "cristellarian" forms. Above these lowermost beds the cristellarians become less noticeable and "flabelline" lagenids and anomalinids share prominence with pelagics.

At Austin the Atco is continuously chalky but fifteen miles north, along the San Gabrial River, there is a recurrence of dark glauconitic shales, above the initial chalk, and in these beds the fauna is once again mainly pelagic. This may indicate that a temporary return to the conditions of Eagle Ford deposition was possible in this off-shore location but impossible in the shallower water toward the San Marcos platform.

At Waco the section is similar to that at Austin with this faunal difference: at Austin the lowest beds of the Atco contain a Citharina, C. cf. wadei (Kelley), which is not present at the Waco locality. The genus Hastigerinella is present in these lower beds but it does not persist through the Atco nor is it reported from younger beds of the upper Cretaceous. It is therefore considered a significant member of the lower Atco fauna. From the following list two other species, Citharina texana (Cushman) and Palmula suturalis (Cushman), have been chosen as having particular importance and will be discussed in a later section of this report.

Atco fauna: alphabetical by genera

Bulimina reussi Morrow
Citharina texana (Cushman)
Citharina cf. C. wadei (Kelley)

Dorothia alexanderi Cushman
Eouvigerina plummerae Cushman
Frondicularia lanceola Reuss var. bidentata Cushman
Gaudryina austinana Cushman
Globorotalites micheliniana (d'Orbigny)
Globotruncana fornicata Plummer
Gumbelina spp.
Gyroidina globosa (Hagenow)
Hastigerinella simplex Morrow
Lenticulina munsteri (Roemer)
Marginulina directa Cushman
Marginulina cf. M. pseudomarcki Cushman
Marsonella oxycona (Reuss)
Nodosaria affinis (Reuss)
Palmula suturalis (Cushman)
Planulina austinana Cushman
Planulina texana Cushman
Rugoglobigerina rugosa (Plummer)

Vinson - Bruceville

The fauna of this middle portion of the lower Austin is similar to that of the earlier part with these three additional species:

Frondicularia goldfussi Reuss
Kyphopyxa christneri (Carsey)
Textularia laevis (Roemer) var. cretosa Cushman

Other species are added in this interval but those listed above can be readily recognized and are probably the most consistently present. Of particular significance is the first occurrence of Kyphopyxa christneri (Carsey) whose origin and inferred value as a time marker will be presented later.

From Austin southward, where the Vinson is recognizable as a nodular chalk, the fauna is sparser both in species and in number of individuals than is the fauna of its stratigraphic equivalent, the Bruceville marl, of the Bell County exposures. However, the cumulative fauna listed above is present consistently in both areas and therefore is considered characteristic of both the Vinson and the Bruceville.

In addition, a stratigraphically localized fauna occurs at the Atco - Bruceville boundary from Waco southward for a distance of fifty miles. At this boundary there is a large amount of biotite in the sediment accompanied by a coarsely arenaceous fauna among which Haplophragmium taylorense Cushman & Waters and Flabellammina clava Alexander & Smith are prominent members. This arenaceous fauna could not be traced farther south at this level but it does reappear at two levels within the Dessau and will be mentioned under the discussion of that stratigraphic unit.

Jonah - Hutchins

This complex of fragmental limestone, called Jonah in the south, interfingering with Hutchins chalk north of the San Gabrial river does not provide any easily recognizable nor characteristic additions to the preexistent fauna. The only differences observed are that the fauna of the Jonah - Hutchins is much sparser than that of the Bruceville - Vinson below, particularly in members of family Lagenidae in the type Austin area and southward toward the platform. At the Fort Griffin locality of the basin area in Bell County the fauna is almost entirely pelagic in the soft Hutchins chalk. The former is to be expected as the fauna of each unit becomes sparser toward the San Marcos platform; the latter, extreme abundance of pelagics, may represent a temporary return to deeper water conditions of perhaps limited circulation in the basin area corresponding to a period of particular shallowing on the platform.

Dessau

At the base of the otherwise chalky Dessau formation, in the type section at Austin, there is a fragmental glauconitic member, designated the Schwertner member by Durham (1957), separated by a disconformity from the underlying Jonah limestone. Across this contact there is little immediate change in the foraminiferal fauna except for a general increase in abundance of all members of the fauna especially in family Lagenidae. The few additional species are inconspicuous except for Anomalina ammonoides (Reuss), usually considered a species of the Taylor fauna, and Valvulineria infrequens Morrow.

Just above the middle of the Dessau, in the Austin area, a recurrence of the coarsely arenaceous fauna, mentioned above, characterized by Haplophragmium taylorense Cushman & Waters and Flabellammina clava Alexander & Smith, suggests correlation with a similar fauna at the same stratigraphic level near the base of the Turnersville Creek section. A further correlation is suggested with a similar fauna about twenty-five miles south of Waco in sample "A" of the Falls County sequence. Both of these correlations involve samples in approximately the same stratigraphic position as the one in the type section of the Dessau. The correlation is strengthened in that the brachiopod Terebratulina filosa and a level of borings, indicating hiatus, occur with the arenaceous fauna in the two southern sections.

The following is a list of additional species in the

Dessau:

Allomorphina trochoides (Reuss)
Anomalina ammonoides (Reuss)
Bulimina reussi Morrow
Dentalina gracilis d'Orbigny
Flabellammina clava Alexander & Smith
Frondicularia austinana Cushman
Frondicularia undulosa Cushman
Haplophragmium taylorense Cushman & Waters
Lenticulina pseudosecans (Cushman)
Valvulineria infrequens Morrow
Ventilabrella eggeri Cushman

Burditt - Big House

The Burditt chalk-marl and the overlying Big House Chalk of Durham (1957) become, as do the other portions of the upper Austin, increasingly marly northward from Austin, Texas. These beds contain an increasingly abundant foraminiferal fauna and are the loci of the earliest occurrence of many foraminifers usually associated with the Taylor marl. However, there is no reason for excluding these beds from the Austin group, on a basis of Foraminifera, since the majority of the fauna is composed of preexistent species and the typically Austin Citharina texana (Cushman) is present throughout.

Among the most prominent forms closely allied to the Taylor is Planulina taylorensis (Carsey). This species appears at the very top of the Big House chalk in the Austin area but occurs in progressively older strata northward as the sediment becomes increasingly marly (Fig. 3). This suggests that Planulina taylorensis (Carsey) is controlled more by facies than by time as evidenced by its presence in marly beds nearly three hundred feet below what Durham's

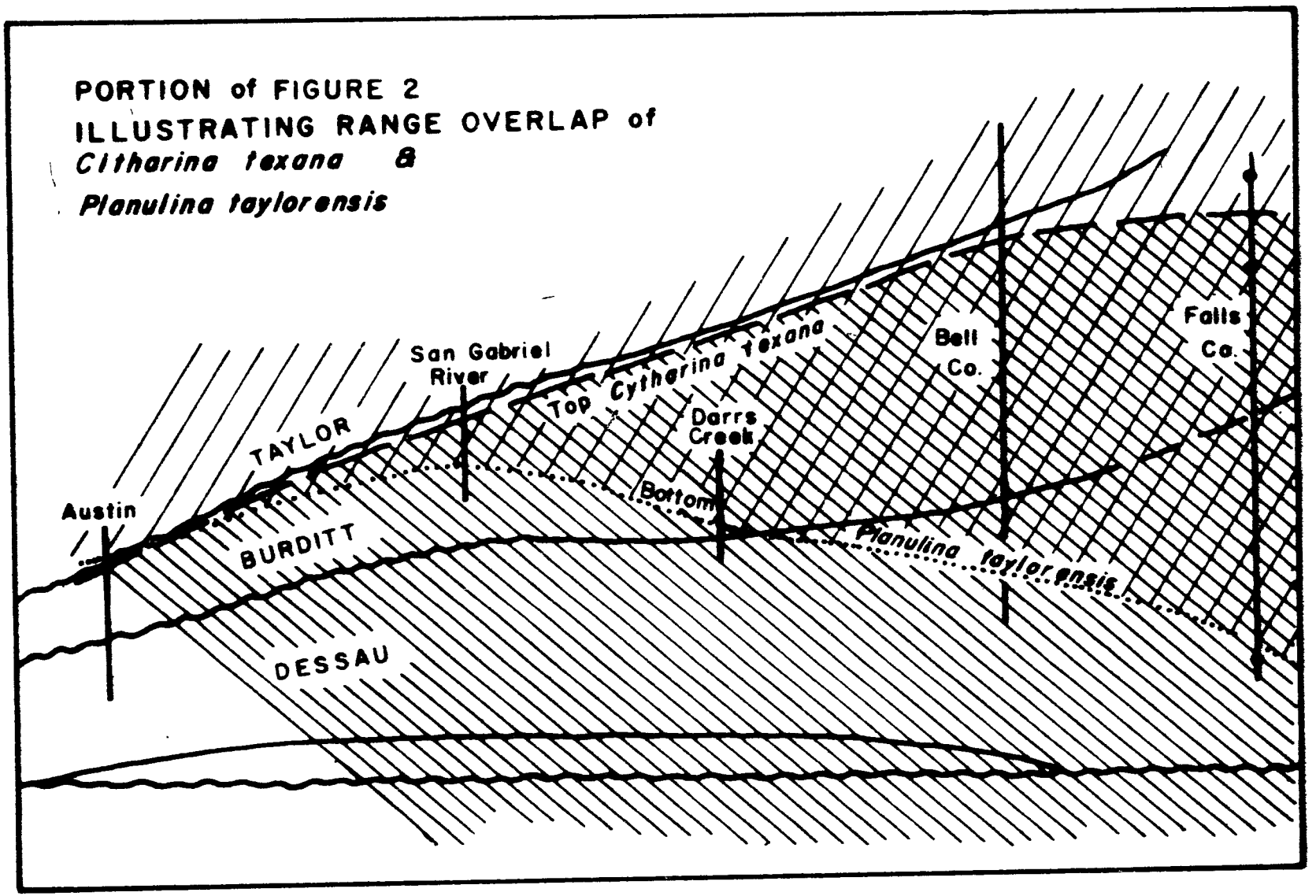
PORTION of FIGURE 2
ILLUSTRATING RANGE OVERLAP of
Citharina texana &
Planulina taylorensis
San Gabriel River
Top Citharina texana
Darrs Creek
Bell Co.
Falls Co.
TAYLOR
Austin
Bottom
BURDITT
Planulina taylorensis
DESSAU

Figure 3

correlation shows to be the Austin - Taylor contact.

The presence of Citharina texana (Cushman) is presented as proof that the Burditt - Big House sequence, and consequently all stratigraphic equivalents, belong in the Austin group. It might be argued that Citharina texana (Cushman) is as indigenous to chalk facies as Planulina taylorensis (Carsey) is to marl and therefore the Citharina could not be a time marker. However, this argument is fallacious because Citharina texana (Cushman) is not limited to a chalk environment as is evident from its presence through the thick marl section in Falls County. In Falls County, the upper limit of Citharina texana (Cushman) south of Waco occurs in a thick marl sequence where no lithologic break appears but at a level which was indicated by Durham (1957) as the Austin - Taylor contact.

The illustration, fig. 3, shows how the line joining the points of earliest occurrence of Planulina taylorensis (Carsey) crosses the line joining the points of latest occurrence of Citharina texana (Cushman). Obviously there is a different control for each species: clay sediments for Planulina taylorensis (Carsey), the Austin - Taylor contact (time) for Citharina texana (Cushman).

Additional species from the Burditt and Big House are:

Heterostomella austiniana (Cushman)
Loxostomum clavatum (Cushman)
Planulina taylorensis (Carsey)
Pseudogaudryinella capitosa (Cushman) var. serrulata (Cushman)
Rectogumbelina hispidula (Cushman)
Verneuilina cretosa (Cushman)
Virgulina tegulata (Reuss)

Taylor

The Taylor beds overlying the Austin in the type area were sampled at eight levels, the uppermost of which is in the base of the Pecan Gap chalk. The lowest Taylor beds, just above the discontinuity which marks the Taylor - Austin boundary, contain a foraminiferal assemblage consisting mainly of Austin forms. The principal differences to be noted are the introduction of several species of delicate Dentalinas, increase in members of family Heterohelicidae, and the introduction of new species of pelagics, particularly Globotruncanas. Other differences are to be found in the better preservation of the specimens and a general tendency for preexistent species to become larger. This general increase of the fauna with no loss of species except Citharina texana (Cushman) gives the whole complex of sediments the appearance of a single continuously deposited unit.

SIGNIFICANT SPECIES

Bases for Selection

Early in this study it became evident that the most striking Foraminifera in the assemblages were the genera of the family Lagenidae. Although never the most abundant forms they are perhaps the most consistently present throughout the area under investigation; are usually in sufficient numbers to be present in any sample; and are represented by a comparatively large number of genera and species which are, for the most part, readily recognizable. In addition there is a progressive change in the forms which suggests that they were evolving during the time of Austin deposition. For these reasons certain members of this family have been chosen for special attention because they appear to have stratigraphic significance within the Austin Group.

Certain coarsely arenaceous forms appear and disappear within short stratigraphic intervals and therefore demand attention. Although not observed continuously across the exposure area at any one level, they are presented as potentially characterizing, at least locally, those intervals in which they appear.

Range

Few species are consistently present in every sample but nearly all have a scattered presence throughout the section above their earliest occurrence. The horizontal distribution is likewise scattered to some extent but the few species chosen as significant show more consistency than most of the

others. From Austin southward onto the San Marcos platform the abundance of Foraminifera decreases steadily; northward the distribution and abundance is much more uniform. The shallowing of the sea southward, as mentioned previously, provided an environment in which the flabelline lagenids would not have flourished, and it is not surprising that these forms, usually associated with deeper less agitated water, are noticeably rare in that area. In spite of this tendency, the Citharina texana (Cushman) and Kyphopyxa christneri (Carsey) maintain their respective positions in the section and are numerous enough to be found in a normal sample.

Value

The two species mentioned above, Citharina texana (Cushman) and Kyphopyxa christneri (Carsey), have obvious value as the position of each is stable in the lower Austin section. Unfortunately, no species with such constant stratigraphic position have been established within the upper Austin. It is somewhat more difficult, therefore, to establish correlation in this portion of the section.

In an attempt to prove, faunally, the truncation of upper Austin beds onto the San Marcos platform as described by Durham(1957) the coarsely arenaceous fauna of the middle Dessau as observed in samples "K" and "L" of the type Dessau section (Locality 11) was considered traceable. A similar fauna occurs in samples "C" and "E" of the Turnersville Creek section. Sample "C", with a single specimen of Flabellammina clava, lies

immediately above a discontinuity surface recognized in the field. Samples "A" and "B" of the section are considered middle Dessau since they contain nothing indicative of any other stratigraphic position. As indicated on Fig. 2, a correlation is suggested between these two points and the occurrence of a similar fauna in sample "A" of Falls County. If this is a true correlation the position of the observed disconformity at Turnersville Creek can be recognized faunally far to the north where no lithic indication of hiatus is observed.

A lower occurrence of an arenaceous fauna containing the same elements was observed in sample "F" of the Vinson Creek section. This sample lies in the lower Dessau beds just above the disconformity marking the top of the Jonah fragmental limestone and is considered correlatable with occurrences in similar stratigraphic position observed in sample "F" of the Big Walnut Creek section Locality 12, and Sample "D" of the Eddy section, Locality 23.

Since this lower occurrence of the arenaceous fauna has not been observed in samples south of the Vinson Creek locality it can be reasoned that the beds containing this fauna are missing and the truncation of the lower Dessau claimed by Durham is indeed a fact.

Another bit of evidence for truncation can be noted at the Cibolo Creek locality about fifteen miles north of San Antonio and about seventy miles south of the Type Dessau locality. In the topmost sample, sample "F" of the Cibolo Creek locality,

Bolivinoides decoratus (Jones) var. decoratus (Jones) and Planulina taylorensis (Carsey) are considered indicative of the lower Taylor position of the beds. A disconformity observable in the field separates sample "F" from sample "E" below it. The fauna of sample "E", although sparse, contains no forms to ally it with the Taylor nor with any part of the uppermost Austin (Burditt or Big House) and it is therefore assigned a position in the Dessau or lower beds.

Northward from the type area at Austin, as mentioned above, the "coarsely arenaceous fauna of the middle Dessau" may establish a horizon for correlation in this portion of the section where facies is changing from chalk to marl northward. The top range of Citharina texana (Cushman) however, is the most valuable species in this portion of the Austin as it does not, as pointed out earlier, appear to be controlled by facies.

EVOLUTIONARY INDICATIONS

Material collected from several localities across the middle of the Vinson - Bruceville section has provided a sufficient number of specimens to indicate that Kyphopyxa christneri (Carsey) is an evolutionary outgrowth from Palmula suturalis (Cushman). From among the large number of specimens of these two species three have been chosen to illustrate the typical end forms and the transitional form. The specimens selected are all from Locality 20 and are illustrated in Fig. 4; specimen No. 1, from sample B, is a typical Palmula, No. 2, from sample C, is a transitional form, and No. 3, from sample E, a typical Kyphopyxa. This change takes place within thirty-three feet of section.

Palmula suturalis (Cushman) is well established in the assemblage in the lower Atco formation and is consistently present in the overlying beds. At about the middle of the Vinson - Bruceville unit Kyphopyxa christneri (Carsey) enters the fauna. Just below this earliest occurrence of the Kyphopyxa a form believed to be transitional between the two coexists with the Palmula; and a few tens of feet above the oldest Kyphopyxa the Palmula drops out of the fauna. These transitional forms show a pair of biserial chambers (No. 2 of Fig. 4) between the initial flabelline chambers and the final sagitate ones. The transition is completed by loss of the flabelline coil and increase in number of biserial chambers to several pairs (No. 3 of Fig. 4). Although Palmula suturalis (Cushman) has been reported from the Gober chalk and

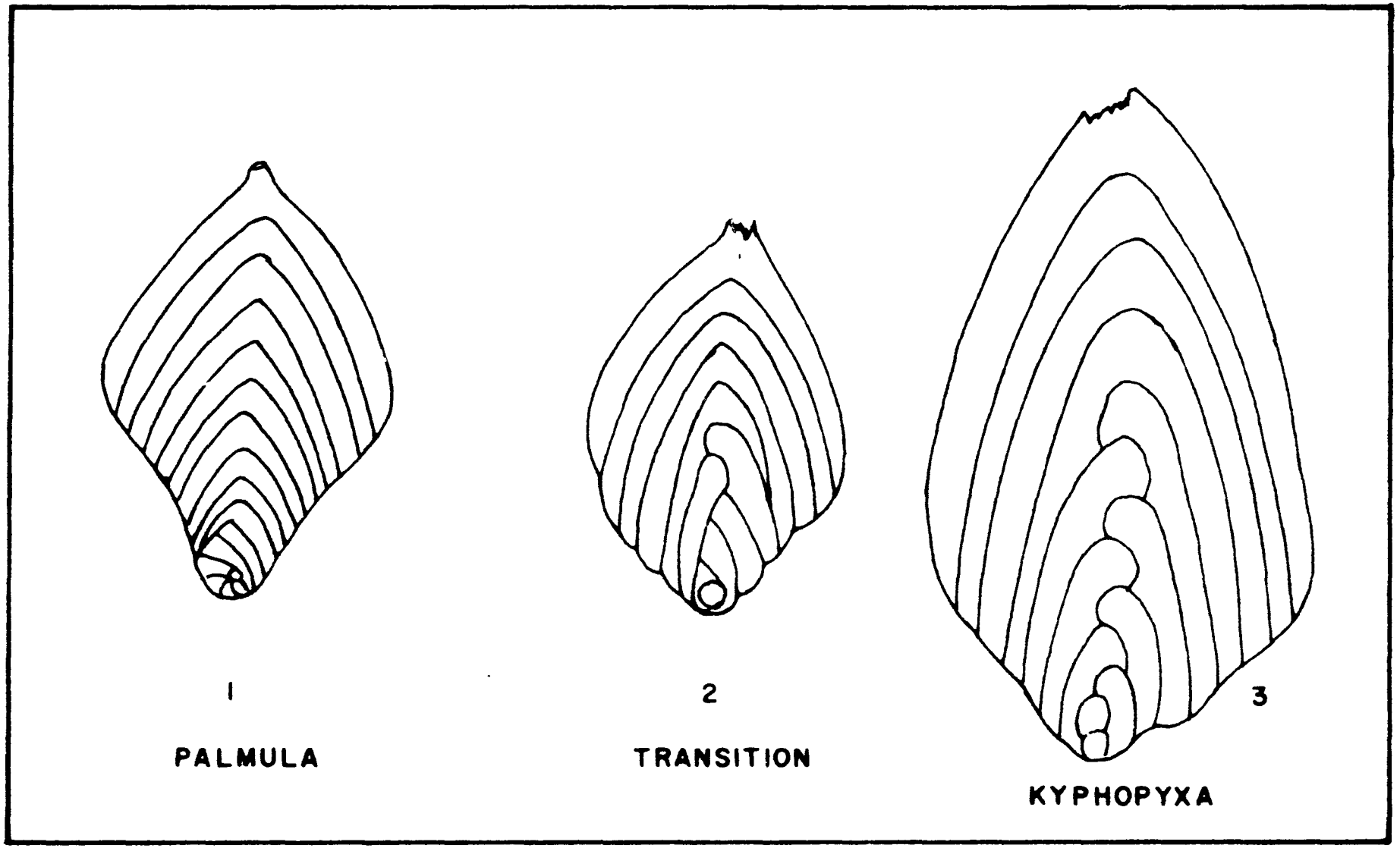

Figure 4
Evolution of Kyphopyxa

the Brownstown marl in the area northeast of Dallas, both considered younger than the Vinson - Bruceville, it has not been found in the present collection above beds considered Vinson equivalents.

SUMMARY AND FUTURE PROBLEMS

In the past there has been only a very general idea of the stratigraphic position of any exposure of Austin sediments. Durham's work has clarified much of the problem in the vicinity of Austin, Texas by showing that stratigraphic equivalents of the upper Austin group in the Waco area are not chalk but clay sediments formerly referred to as "Taylor" marls. This careful stratigraphic work has provided a background against which samples of known position in the total sequence have been collected for the present investigation of the foraminiferal fauna.

Up to the present over one hundred fifty species of Foraminifera have been described from strata considered "Austin chalk" but the present author concurs in the opinion of McNulty (1955) that very few of that number are consistently present at all levels of the Austin and an even smaller number could be said to characterize these beds. The writer has found only one species, Citharina texana (Cushman), which becomes extinct at the upper boundary of the "Austin" as defined by Durham.

This lack of extinction at the top of the Austin group indicates continuous deposition across the Austin - Taylor boundary northward from Austin, Texas and little more than discontinuity of deposition in the "type" area at Austin. It is therefore thought that the presence of Citharina texana (Cushman) in the lower portion of the clay section above the chalk at Waco further indicates the Austin equivalence of

these beds as predicted by Durham.

Although not limited to the Austin group, many foraminifers make their earliest appearance within it. Notable among these is Kyphopyxa christneri (Carsey) which evolves from Palmula suturalis (Cushman) within the lower portion of the group. The level of this evolution can be considered a time line of at least local extent. It is further significant that this level parallels very closely the correlation lines of Durham's stratigraphic grid (Fig. 2).

In addition to these markers at least two zones marked by a fauna characterized by Flabellammina clava Alexander & Smith and Haplophragmium taylorense Cushman & Waters were discovered in the Dessau member of the Austin group. These are shown to be useful in local correlation by the fact that these zones also follow the correlation lines on the stratigraphic grid. The significance of a similar zone in the lower Austin of the Waco area has not yet been established.

It is hoped that these species can be found consistently in other areas, particularly in the thick marl sequence between Waco and Dallas. Such findings would help materially to establish the synchroneity of the different lithologies. Further extension southward into the Rio Grande embayment and Mexico would complete the nucleus of a basic concept of foraminiferal distribution within the Austin and Taylor sediments.

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BIBLIOGRAPHIC NOTE

The recent Ph. D. dissertations, McNulty, 1955 and Durham, 1957, provide an almost complete bibliography of the Austin Group. In order to avoid redundancy only those papers consulted to by the writer are included here as selected references.

A P P E N D I X

LIST OF AUSTIN GROUP LOCALITIES

1. Cibolo Creek
2. Wasserfall der Guadeloupe
3. Onion Creek
4. Turnersville Creek
5. Vinson Creek
6. Williamson Creek
7. Little Walnut Creek at New Manor Rd. 226-T-42
8. Little Walnut Creek at Old Manor Rd. 226-T-4
9. Big Walnut Creek downstream from Highway 1325 226-T-38
10. Big Walnut Creek at New Highway 81 crossing
11. Dessau Rd. Ditches along road ascending hill from small creek
12. Big Walnut Creek downstream from creek mentioned in # 11
13. Stoney Creek downstream from R.R. bridge west of Hutto on Highway 79
14. San Gabriel River 2 miles upstream from Jonah
15. San Gabriel River 1 mile upstream from Jonah, Big Bluff
16. San Gabriel River just downstream from low water crossing at Jonah
17. San Gabriel River 1½ miles downstream from Jonah, near confluence of Big House Branch
18. South Darr's Creek South of Holland
19. Darr's Creek 1 mile West of Holland
20. Tributary of Salado Creek near Sommer's Mill

20-A. Campbell's Branch, 2 miles east of Locality 20

21. Hartrick's Bluff and Fort Griffin along Leon River

21-A. Tributary of Leon River, 1 mile north of Locality 21

22. Bell County samples A, B, and C collected along Highway 53

25-A. Barrow pit on Highway No. 6 south of Waco, Texas

25-B. Exposures along an abandoned road just north of Locality 25-A

25-C. Emmon's Bluff, Cameron Park, Waco, Texas

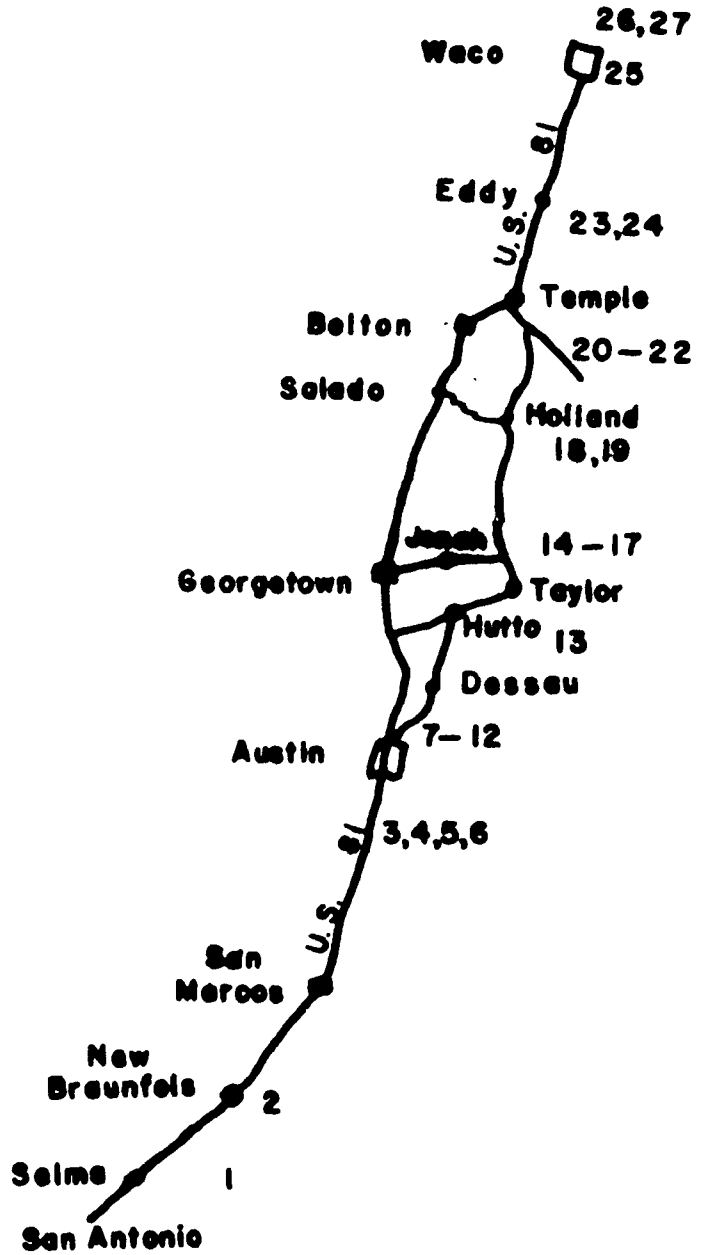
25-D. Circle Bluff, Cameron Park, Waco, Texas

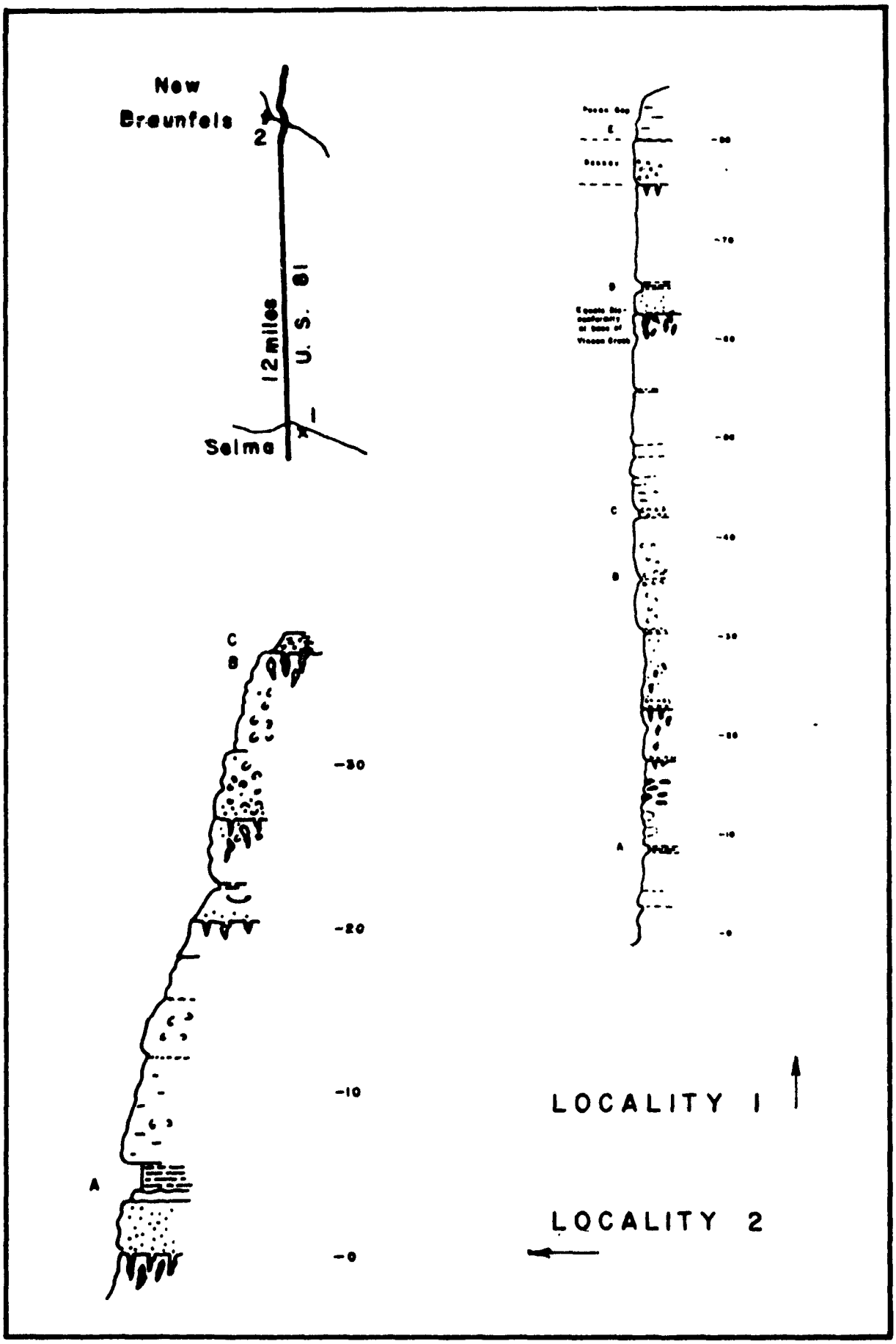
25-E. Lovers Leap, Cameron Park, Waco, Texas

26. White Rock Creek

27. Chalk Bluff on Brazos River

INDEX MAP FOR AUSTIN LOCALITIES

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LOCALITY 1
LOCALITY 2

LOCALITY 1, CIBOLO CREEK

Sample A

Material is highly indurated chalk and washes with extreme difficulty.
Glauconite frequent.
No slide picked as only one specimen of Globigerina was observed.

Sample B

Material similar to above.

Citharina texana	rare
Palmula suturalis	rare
Lenticulina munsteri	rare
Pelagic forms	rare
Textularia sp.	rare
Anomalinids	rare

Sample C

Material as above. No slide picked.

Sample D

Material washed satisfactorily to a large residue with abundant glauconite and shell fragments.

Kyphopyxa christneri	rare
Palmula suturalis	frequent
Citharina texana	frequent
Textularia sp.	frequent
Haplophragmium ?	frequent
Anomalinids	common
Pelagics	common

Sample E

Material of poor quality. No slide picked.

Sample F

Material washed with great difficulty due to induration.
Sparse fauna.

Bolivinoides decoratus (?)	rare
Globorotalites conicus	rare
Anomalinids	frequent

WASSERFALL DER GUADALUPE, LOCALITY 2

Sample A

Material washed well to a copius concentrate.

Kyphopyxa christneri	rare
Citharina texana	common
Palmula suturalis	common
Marginulina austinana	rare
Lenticulina munsteri	rare
Nodosaria sp.	rare
Textularia sp.	common
Haplophragmium	common

Sample B

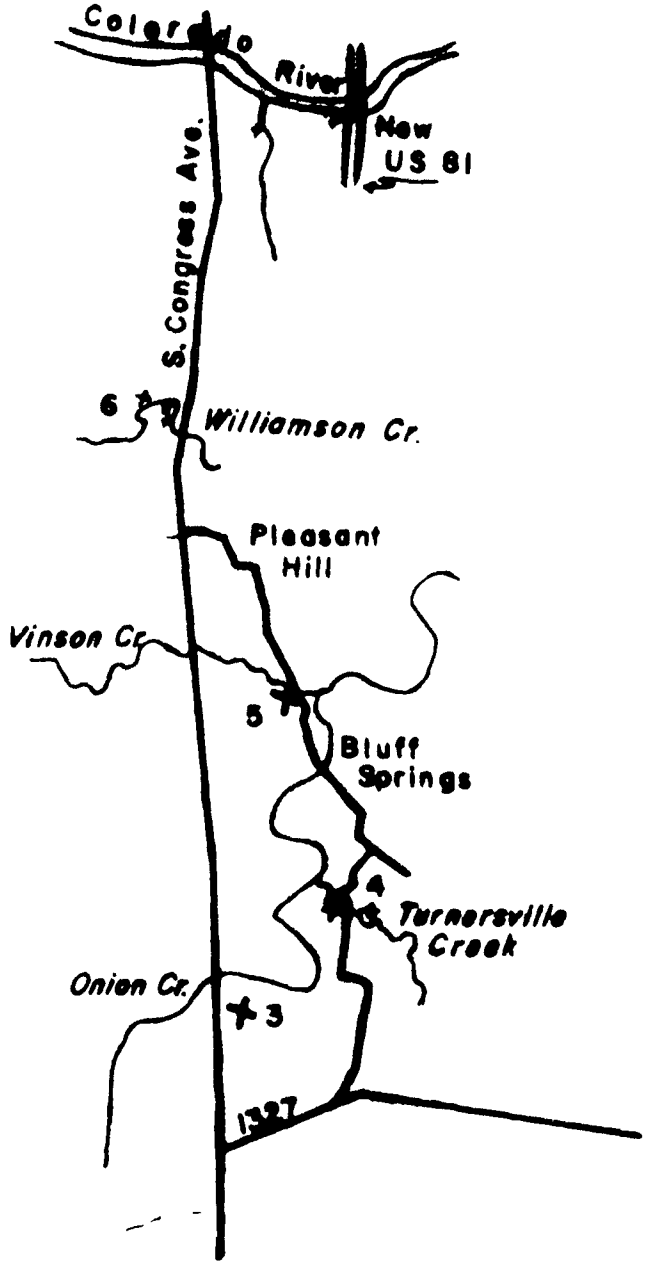
Glauconitic marl filling bore holes. Sparse fauna similar to that of the Dessau.

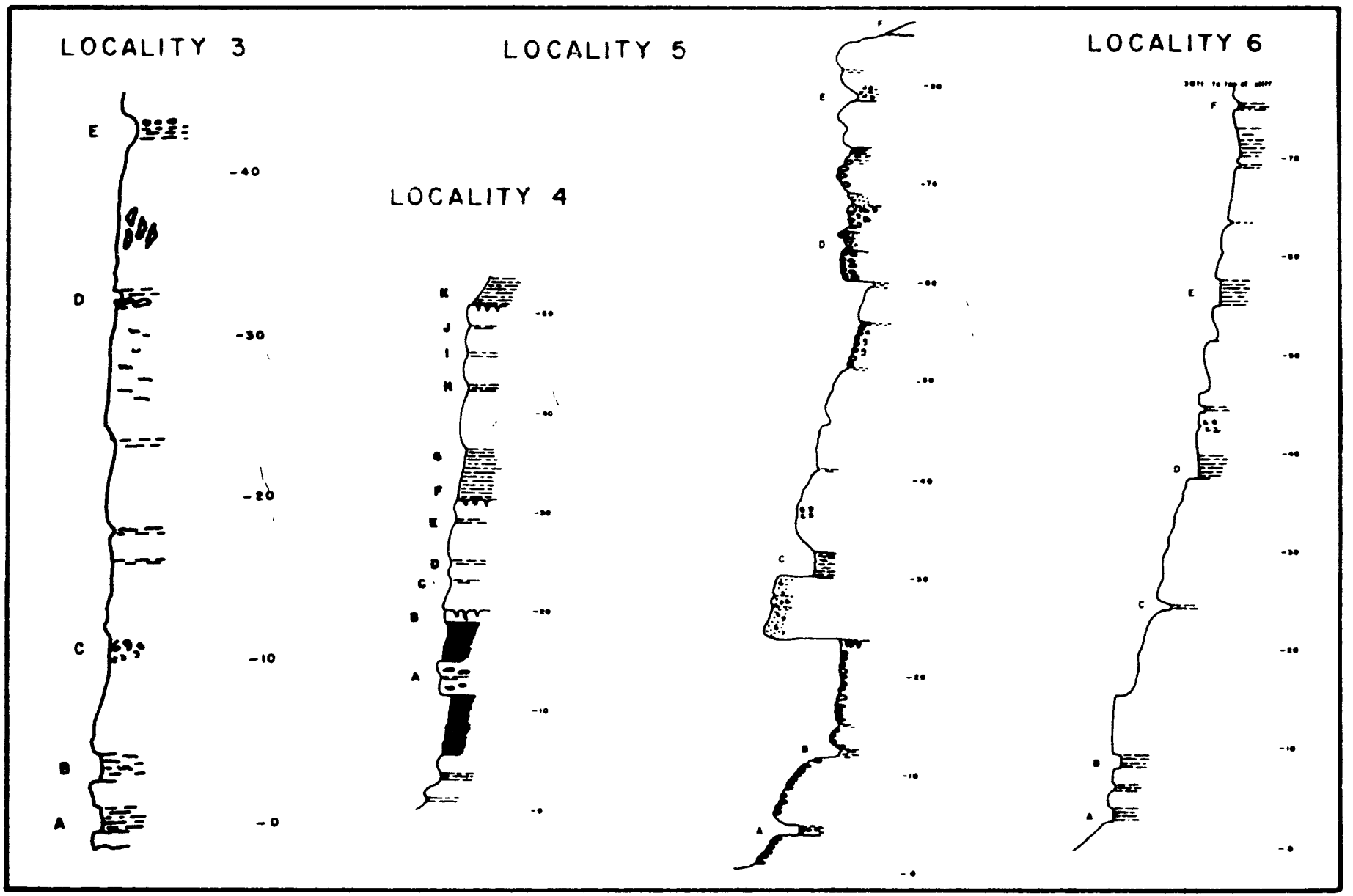
Sample C

Material looks and washes like Taylor. Small clean concentrate.

Small pelagic forms	dominant
Lagenids	frequent
Anomalinids	rare
Elipsonodosaria sp.	frequent
Bolivina sp.	rare

LOCALITIES SOUTH OF AUSTIN




LOCALITY 3
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ONION CREEK, LOCALITY 3

Sample A

Chalk is recrystalized, washed with difficulty, specimens seldom clean.

Citharina texana	rare
Marginulina austinana	rare
Lenticulina munsteri	common
Palmula suturalis	rare
Frondicularia lanceola	rare
Planulina sp.	common
Textularia spp.	common
Pelagics	common

Sample B

Material less indurated than sample A, fauna abundant and same as sample A.

Sample C

Material and fauna like sample A.

Sample D

Material and fauna like sample A.

Sample E

Material and fauna like sample A.

TURNERSVILLE CREEK, LOCALITY 4

Sample A

Coarse calcarenite with abundant glauconite and shell fragments washed to a large concentrate. Fauna copius but obscured by mass of sample.

Citharina texana	rare
Kyphopyxa christneri	rare
Frondicularia lanceola	rare
Marginulina austinana	rare
Gaudryina austinana	common
Anomalinids	common
Pelagics	common

Sample B

Glauconitic chalk with sparse fauna, similar to previous sample.

Sample C

Coarse calcarenite with fish vertebrae and rare glauconite. Fauna as in previous samples but with:

Flabellammina clava	rare
Textularids	frequent

Lagenids more abundant

Sample D

Same as previous.

Sample E

Same as previous but with:

Haplophragmium taylorense frequent

Sample F

Very glauconitic calcarenite; fauna very sparse.

Haplophragmium not present

Sample G

Same as previous.

Sample H

Same as previous but with:

Haplophragmium taylorense frequent

LOCALITY 4, continued

Sample I

Same as previous.

Sample J

Same as previous but without Haplophragmium taylorense.

Sample K

Soft marly material washed to small concentrate with the appearance of "Taylor."

Planulina taylorensis (typical forms)	Common
Lagenids, slender and fragile	Common
Citharina texana absent	

VINSON CREEK, LOCALITY 5

Sample A

Clean wash but not large reduction in volume of material.

Gaudryina rudita	frequent
Marsonella pxycona	rare
Textularia spp.	frequent
Citharina texana	frequent
Lenticulina munsteri	frequent
Palmula suturalis	frequent
Anomalinids	common
Pelagics	common

Sample B

Same as sample A

Sample C

Same as sample A with the following addition:

Kyphopyxa christneri	rare

Sample D

Very indurated material washed with great difficulty;
glauconite abundant
very sparse fauna consisting of anomalinids, textularias, and rare pelagics.

Sample E

Same as sample D.

Sample F

Easily washed material reduced to about one sixth of original.
Glauconite common

Arenaceous fauna containing:

Haplophragmium taylorense	frequent
Flabellammina clava	rare
Lituola sp.	abundant
Gaudryina	abundant

Kyphopyxa christneri	frequent
Marginulina austinana	rare
Dentalina sp.	rare
Lenticulina munsteri	rare
Frondicularia lanceola	frequent
Nodosaria affinis	rare

VINSON CREEK, LOCALITY 5 continued

Sample F continued

Lagena sp.	rare
Anomalinids	common
Pelagics	common

Citharina texana is notably absent from this sample.

WILLIAMSON CREEK, LOCALITY 6

Sample A

Material washes easily to a clean concentrate. Fauna prolific.

Lenticulina munsteri	frequent
Palmula suturalis	rare
Citharina texana	rare
Citharina cf wadei	rare
Marginulina austinana	rare
Nodosaria affinis	rare
Marsonella sp.	frequent
Textularia spp.	rare
Pelagics	abundant
Anomalinids	abundant

Sample B

Material mineralized but provides a clean concentrate. Fauna same as sample A.

Sample C

Hard chalk almost impossible to wash; no slide as only very few fragments of Foraminifera seen.

Sample D

Sandy marl provides a large concentrate with only a moderate fauna similar to that of sample A.

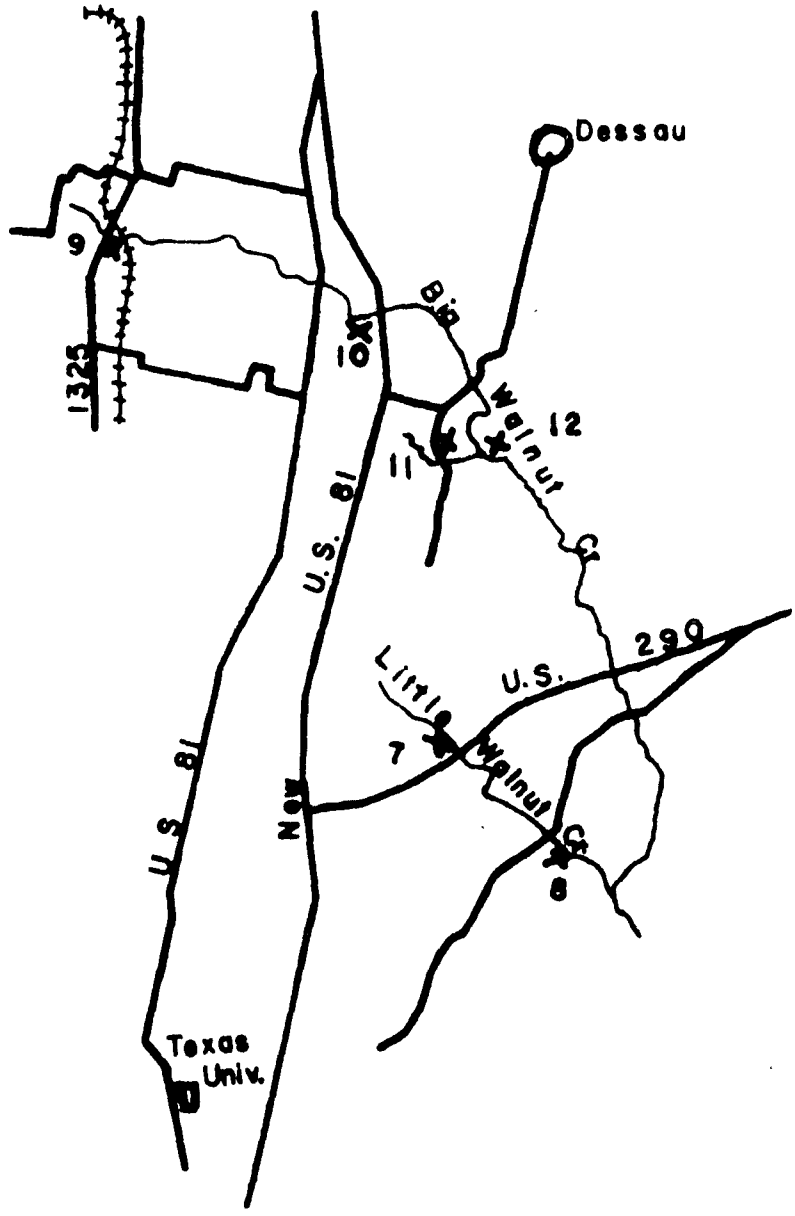
Sample E

Soft material provided a small amount of well washed concentrate. Fauna rather sparse but similar to that of sample A.

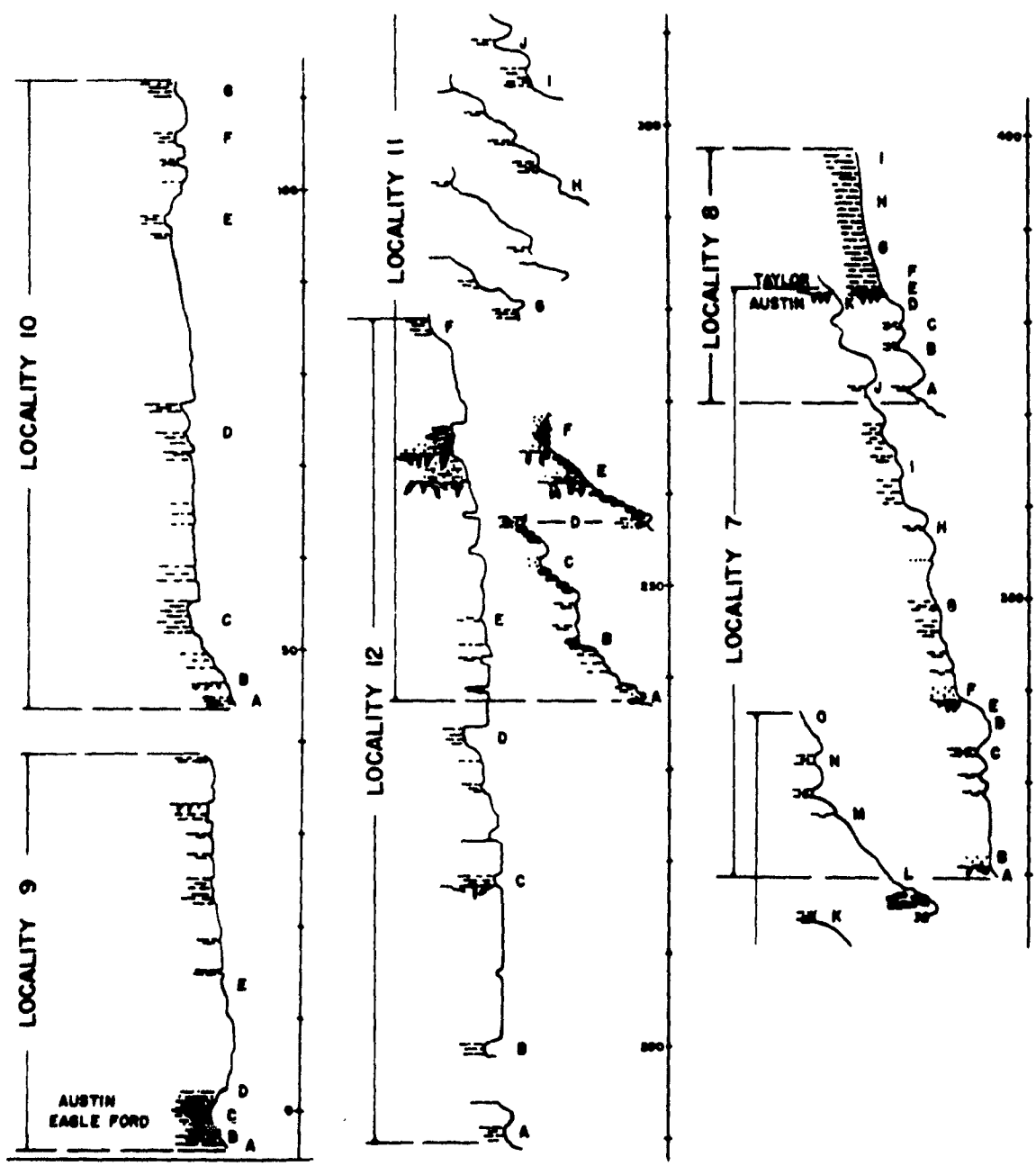
Sample F

Same as sample E.

LOCALITIES NORTH OF AUSTIN



THE LOCALITIES NORTH OF AUSTIN PRESENTED AS A CONTINUOUS SECTION



LITTLE WALNUT CREEK AT NEW MANOR ROAD, LOCALITY 7

Sample A

Hard chalk washed with difficulty, sparse fauna consisting almost entirely of anomalinids and pelagics. Rare glauconite.

Sample B

Material washed to a large but clean concentrate.

Flabellammina clava	frequent
Haplophragmium taylorense	rare
Gaudryina austinana	common
Dorothia sp.	frequent
Textularia spp.	rare
Kyphopyxa christneri	frequent
Frondicularia undulosa	rare
Marginulina austinana	rare
Lenticulina munsteri	rare
Amomalinids	common
Pelagics	common

Sample C

Soft material washed with ease. Fauna same as sample B, add Citharina texana rare.

Sample D

Similar to sample C but sparser fauna but without Flabellammina clava.

Sample E

Very glauconitic, difficult to wash, fauna extremely sparse. No slide made.

Sample F

Soft material washed to a small concentrate, fauna abundant.

Additional species:

Verneuilina cretosa	rare
Heterostomella austinana	frequent
Anomalinina ammonoides	abundant
Ventilabrella eggeri	rare

Sample G

Missing

LOCALITY 7, continued

Sample H

Soft material washed with ease to a clean concentrate.

Same fauna as previously with addition of Loxostomum clavatum.

Sample I

Same as before.

Sample J

Same as previous samples with the addition of:

Virgulina sp.	rare
Bulimina reussi	rare

Sample K

Same as before with addition of:

Planulina taylorensis	frequent

LITTLE WALNUT CREEK AT OLD MANOR ROAD, LOCALITY 8

Sample A

Material washes easily to a concentrate containing a rich fauna. This is type locality for Vaginulina regina Plummer now considered Citharina texana (Cushman).

Pseudogaudryinella capitosa var. serrulata	frequent
Citharina texana	frequent
Kyphopyxa christneri	frequent
Frondicularia lanceola var bidentata	frequent
Lenticulina munsteri	common
Dentalina spp.	rare
Textularids	frequent
Anomalinids	abundant
Pelagics	abundant
Buliminids	frequent

Sample B

Same as sample A

Sample C

Same as sample A with addition of:

Ventillabrella eggeri	rare
Loxostomum sp.	rare
Gaudryina austinana	rare

Sample D

Same as samples previous.

Sample E

Same as before but concentrate is almost entirely composed of Foraminifera with the notable addition of:

Planulina taylorensis	frequent
Virgulina sp.	rare
Bulimina sp.	rare
Eouvigerina sp.	rare
Saracenaria sp.	rare
Dentalina spp.	rare

Sample F

Same as before but without Citharina texana.

LOCALITY 8, continued

Sample G

Similar to the previous samples of this locality but with the addition of: frail, slender lagenids, and more robust Planulina taylorensis.

Sample H

Same as above; very varied and abundant fauna dominated by pelagics, Buliminids, and Heterohelicids.

Sample I

Same as before.

BIG WALNUT CREEK DOWNSTREAM FROM HIGHWAY 1325
Locality 9

Sample A

Dark shale washed to large residue with much marcasite and mineralized shell fragments. Sparse fauna consisting of:

Rugoglobigerina rugosa	abundant
Globotruncana cf fornicata	frequent
Gumbelina spp.	abundant
Hastigerinella simplex	rare
Haplophragmoides (?) sp.	frequent

Sample B

Same

Sample C

Chalky marl washed to a large concentrate with an abundant fauna.

Pelagics as before	
Lenticulina munsteri	frequent
Citharina cf wadei	frequent
Nodosaria affinis	rare
Frondicularia verneuiliniana (?)	rare
Planulina texana	frequent

Sample D

Same as previous with these additions:

Gyroidina globosa	rare
Globorotalites micheliniana	rare
Gaudryina austinana	rare

Sample E

Hard chalk washed with difficulty and furnished poor fauna. Same as above.

BIG WALNUT CREEK AT NEW HIGHWAY 81 CROSSING
LOCALITY 10

Sample A

Fairly hard chalk furnished only a fair washed concentrate with a limited fauna

Pelagics	abundant
Palmula suturalis	frequent
Citharina cf wadei	rare
Nodosaria affinis	rare
Lenticulina munsteri	frequent
Gyroidina globosa	frequent
Planulina austinana	abundant
Marsonella oxycona	rare
Gaudryina (?) sp.	rare
Marginulina pseudomarcki	rare

Sample B

Same as sample A

Sample C

Similar to previous samples but much richer fauna including these additions:

Gaudryina sp.	common
Textularia spp.	common
Dorothia alexanderi	common
Citharina texana	rare
Marginulina austinana	rare
Eouvigerina plummerae	rare
Bulimina reussi	common
Virgulina sp.	rare

Sample D

Same as previous samples.

Sample E

Same as previous samples.

Sample F

Same as previous samples.

Sample G

Fauna same as previous samples but abundant biotite present.

DESSAU ROAD SECTION, LOCALITY 11

Sample A

Hard chalk, poor wash and sparse fauna.

Textularia sp.	rare
Citharina texana	rare
Anomalinids	common
Pelagics	frequent

Sample B

Same as previous sample but with:

Globorotalites conicus	rare

Sample C

Much richer fauna than previous, including:

Marginulina austinana	rare
Frondicularia inversa	rare
Lenticulina munsteri	rare
Valvulineria infrequens	frequent
Cibicides cf. stephensoni	frequent

Sample D

Same as before plus:

Dorothia alexanderi	common

Sample E

Increase in number of specimens and species:

Marsonella oxycona	common
Kyphopyxa christneri	rare

Sample F

Poor fauna, no additional species.

Sample G

Similar to previous samples.

Sample H

Fauna much richer than before, including:

Frondicularia lanceola	frequent

LOCALITY 11, continued

Sample H, continued

Marginulina pseudomarcki	rare
Eouvigerina aculeata	rare
Bulimina reussi	frequent

Sample I

Similar but richer fauna

Ventillabrella eggeri	rare
Lagena spp.	rare
Dentalina sp.	rare

Sample J

Same as previous sample.

Sample K

Soft material washed with greater ease than previous samples.

Fauna much more varied and including the following new members:

Haplophragmium taylorense	rare
Planulina texana	frequent
Allomorphina sp.	rare
Dentalina gracilis	rare
Frondicularia austinana	rare
Nodosaria affinis	rare

Sample L

Same as previous sample with addition of:

Flabellammina clava	rare

Sample M

Same with these additions:

Lituola irregulariter	rare
Lenticulina pseudo-secans	frequent
Frondicularia undulosa	rare

Sample N

Same as previous sample.

Sample O

Same as previous sample.

BIG WALNUT CREEK, LOCALITY 12

Sample A

Chalky material washed to large concentrate with only a sparse fauna.

Kyphopyxa christneri (transitional forms only)	rare
Citharina texana	rare
Marginulina austinana	rare
Pelagics	rare
Anomalinids	rare

Sample B

Same as previous but somewhat more numerous specimens.

Sample C

Same as previous but with typical Kyphopyxa christneri.

Sample D

Same as previous.

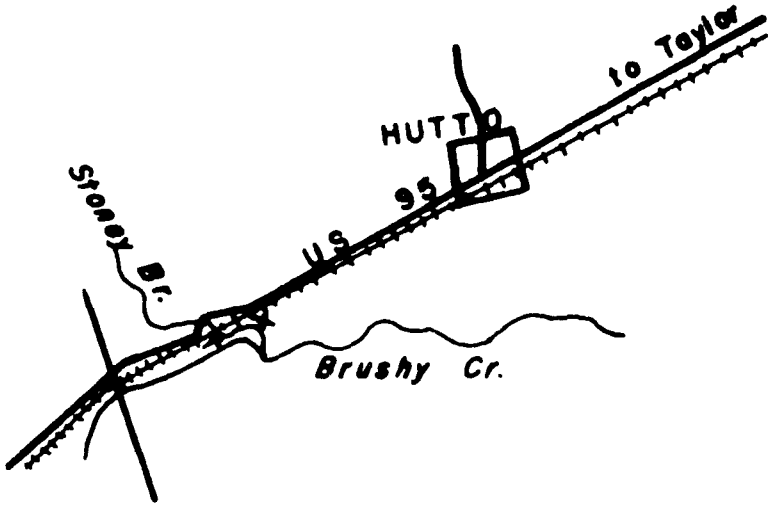
Sample E

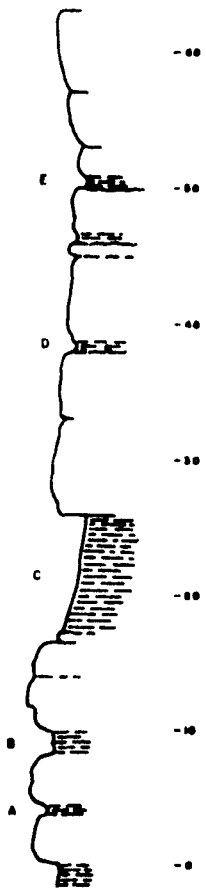
Same as previous.

Sample F

Very glauconitic calcarenite. Increased fauna includes:

Gaudryina austinana	frequent
Frondicularia lanceola	rare
Nodosaria affinis	rare
Textularids	rare
Lenticulina munsteri	frequent





LOCALITY 13

STONEY CREEK, LOCALITY 13

Sample A

Chalky marl washes to a rather large concentrate with many shell fragments and common Foraminifera.

Palmula suturalis	frequent
Transitional Kyphopyxa christneri	rare
Citharina texana	Common
Lenticulina munsteri	common
Marginulina austinana	frequent
Nodosaria affinis	frequent

Sample B

Same as previous.

Sample C

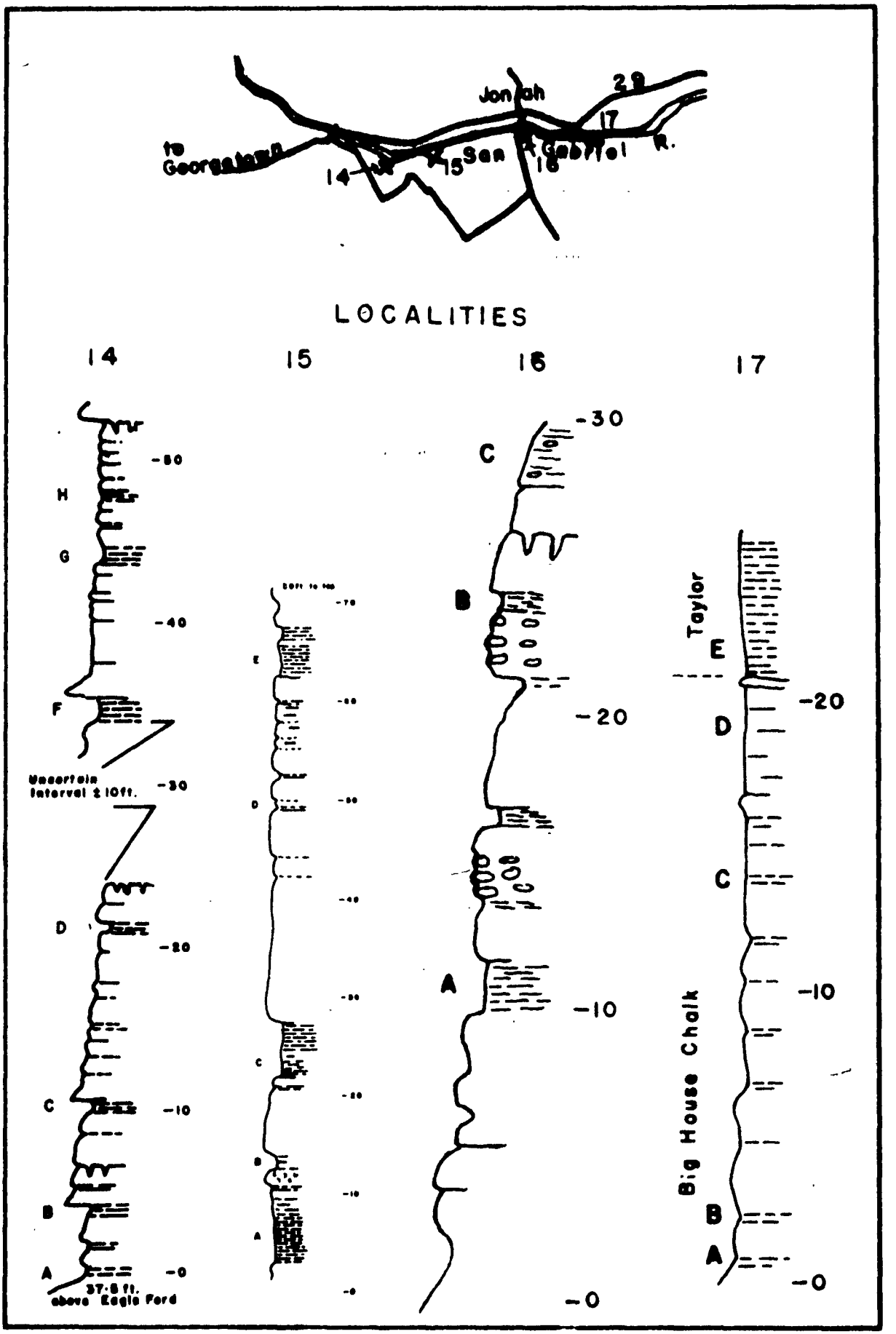
Same as previous.

Sample D

Same as previous.

Sample E

Same as previous with addition of typical Kyphopyxa christneri.


Jonah
29
17
to
14
15
San
16
R.
LOCALITIES
14
15
16
17
-30
-20
-10
-0
H
G
F
E
D
C
B
A
Uncertain
interval ± 10ft.
37.5 ft.
above Eagle Ford
Taylor
Big House Chalk

SAN GABRIEL RIVER, LOCALITY 14

Sample A

Coarsely granular chalk with large amount of marcasite.

Pelagics dominate fauna and include Hastigerinella

Frondicularia lanceola	rare
Frondicularia inversa	rare
Lenticulina munsteri	frequent
Anomalinids	frequent

Sample B

Same as previous.

Sample C

Same as previous.

Sample D

Same as previous.

Sample E

Same as previous.

Sample F

Same as previous.

Sample G

Chalky material washed more completely than the previous samples and contains little marcasite. Concentrate consists largely of shell fragments and forams.

Citharina texana	rare
Palmula suturalis	frequent
Nodosaria affinis	common
Lenticulina munsteri	frequent
Pelagics	abundant

Sample H

Same as sample G.

Sample I

Hard chalk could not be washed satisfactorily; only a few pelagic forms observed and no slide made.

SAN GABRIEL RIVER, LOCALITY 15

Sample D

Chalky marl washes easily to a moderate sized concentrate of shell fragments and Foraminifera. The fauna is dominated by pelagics but benthonic forms are abundant.

Citharina texana	frequent
Palmula suturalis	frequent
Lenticulina munsteri	common
Frondicularia lanceola	frequent
Marginulina austinana	frequent
Nodosaria affinis	rare
Marsonella oxycona	frequent
Textularids	frequent
Anomalinids	abundant

Sample E

Same as previous but with typical Kyphopyxa christneri.

Samples A, B, & C were also worked and have a fauna of the same type as listed above.

SAN GABRIEL RIVER AT JONAH, LOCALITY 16

Sample A

Chalky calcarenite washed easily to a rather large concentrate consisting of shell fragments and Inoceramus prisms with much secondary calcite. Foraminifera are rare and dwarfed.

Anomalinids	frequent
Textularids	frequent
Pelagics	rare
Citharina texana	rare
Lenticulina munsteri	rare

Sample B

Same as previous but Foraminifera more abundant.

Sample C

Very glauconitic marl with large amount of secondary calcite. Foraminifera abundant but dwarfed as before.

Pelagics	common
Lagenids	very rare

SAN GABRIEL RIVER, 1½ MILES DOWNSTREAM FROM JONAH LOCALITY 17

Sample A

Material washed clean to a large concentrate. Biotite and marcasite common.

Haplophragmium taylorense	frequent
Gaudryina austinana	abundant
Textularids	rare
Pelagics	abundant
Lenticulina munsteri	frequent
Citharina texana	frequent
Other large lagenids	frequent

Sample B

Same as previous sample.

Sample C

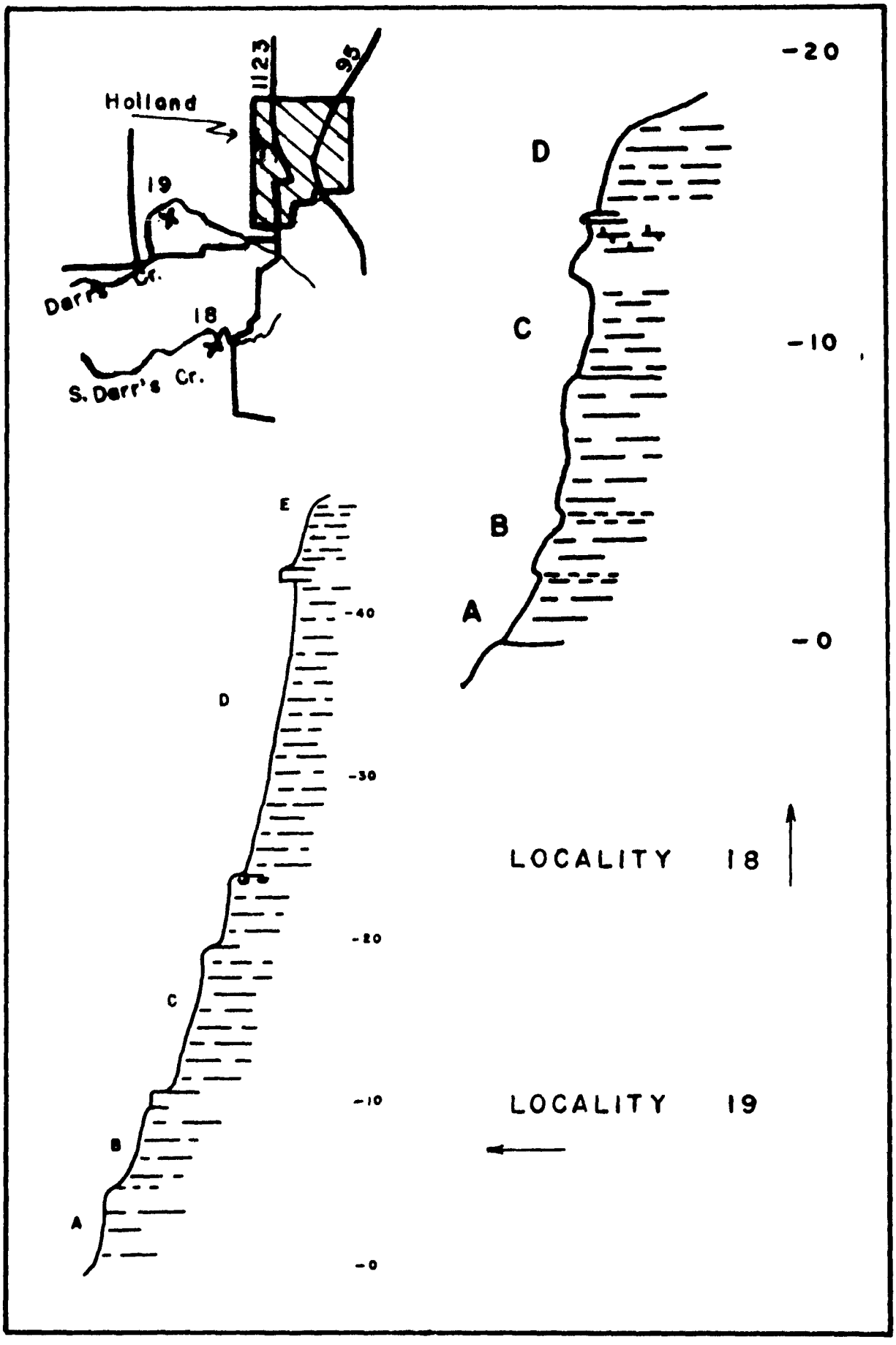
Same as previous samples but a harder chalk.

Sample D

Same as sample C.

Sample E

Same but somewhat more varied fauna than previous.


1123
95
Holland
19
Darr's Cr.
18
S. Darr's Cr.
-20
D
C
-10
B
A
-0
E
-40
D
-30
-20
C
-10
B
A
-0
LOCALITY 18
LOCALITY 19

SOUTH DARRS CREEK, LOCALITY 18

Sample A

Chalky clay washed to clean and small concentrate.

Textularids	frequent
Lagenids	frequent
Anomalinids	common
Pelagics	abundant
Buliminids	common

Sample B

Same as previous.

Sample C

Same as previous with all groups more numerous.

Sample D

Same as previous.

DARRS CREEK, LOCALITY 19

Sample A

Material washed easily to a rather large concentrate containing much glauconite and an abundant fauna.

Large arenaceous forms	abundant
Large lagenids	abundant
Buliminids	rare
Anomalinids	common
Pelagics	abundant

Sample B

Same as previous.

Sample C

Same with the addition of:

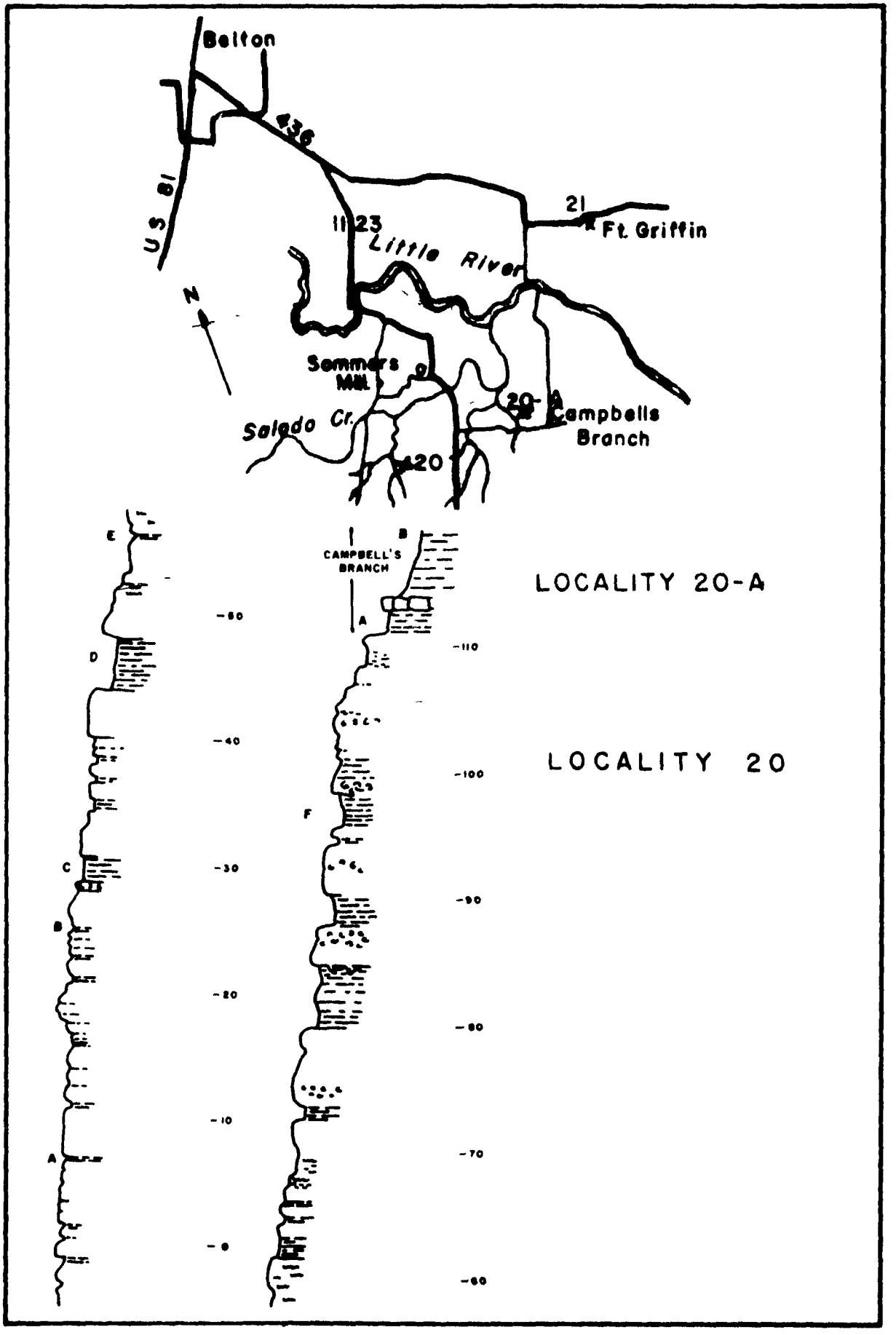
Haplophragmium taylorense	frequent

Sample D

Same as previous but large lagenids less frequent.

Sample E

Same as previous.


Belton
436
US 81
1123
Little River
21
Ft. Griffin
N
Sommers Mill
Salado Cr.
20
20
Campbells Branch
CAMPBELL'S BRANCH
LOCALITY 20-A
LOCALITY 20
E
D
C
B
A
F
-50
-40
-30
-20
-10
-0
-110
-100
-90
-80
-70
-60

TRIBUTARY OF SALADO CREEK, LOCALITY 20

Sample A

Chalky material but soft enough to give a good clean wash.

Textularids	frequent
Lenticulina munsteri	common
Palmula suturalis	frequent
Citharina texana	frequent
Frondicularia lanceola	frequent
Nodosaria affinis	frequent
Marginulina austinana	frequent
Anomalinids	abundant
Pelagics	abundant

Sample B

Indurated material eashed to about $\frac{1}{2}$ original weight.

Haplophragmium taylorense	abundant
Frondicularia lanceola	frequent
Marsonella oxycona	frequent

Otherwise fauna as in sample A

Sample C

Soft marly material of the Bruceville, washed to small residue containing a somewhat more varied fauna than previous.

Sample D

Same as sample C with addition of transitional forms of Palmula suturalis to Kyphopyxa christneri.

Sample E

More chalky material does not wash as easily, residue large; otherwise similar to previous sample.

Sample F

Material rather indurated reduced to about 20% of original.

Kyphopyxa christneri	common
Citharina texana	rare
Lenticulina munsteri	common
Nodosaria affinis	frequent
Textularids	common
Gaudryina	frequent
Pelagics	abundant
Anomalinids	abundant

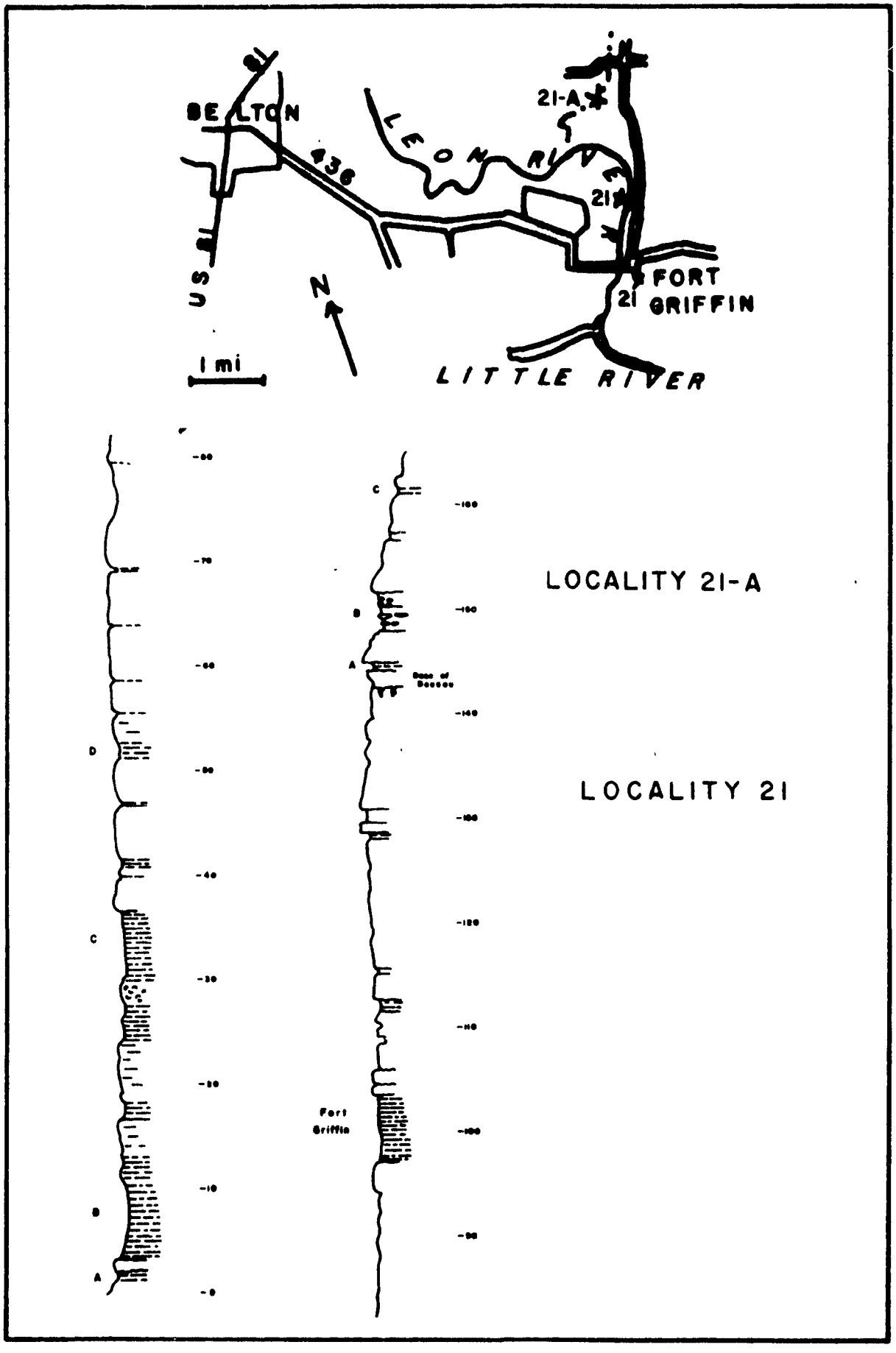
CAMPBELL'S BRANCH, LOCALITY 20-A

Sample A

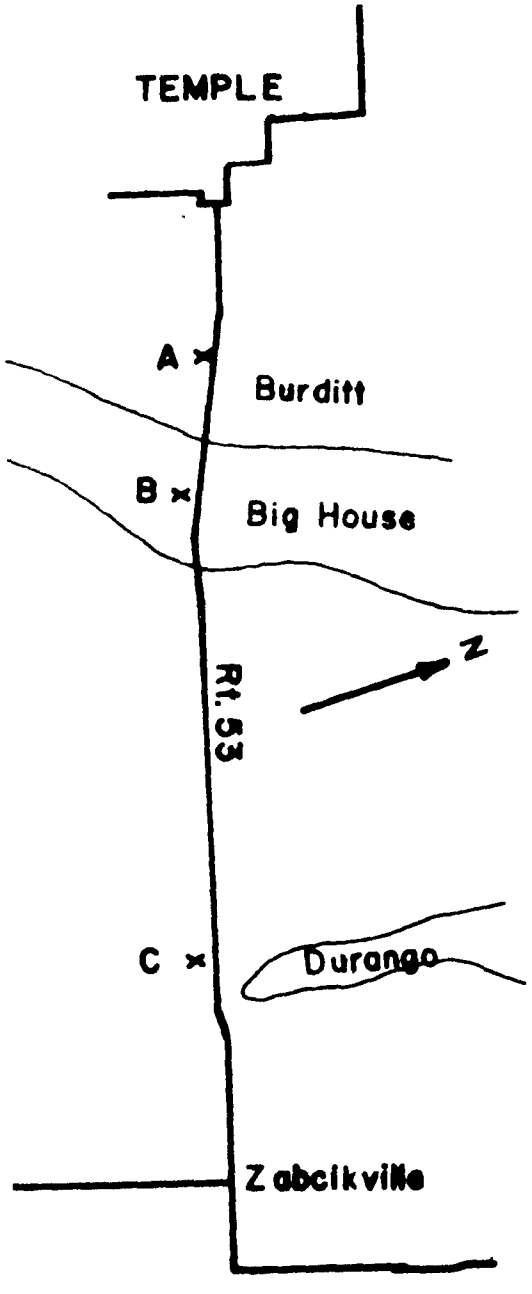
Same as sample F of Locality 20.

Sample B

Same as previous.


BELTON
US 81
436
LEON RIVER
21-A
21
FORT GRIFFIN
21
N
1 mi
LITTLE RIVER
LOCALITY 21-A
LOCALITY 21
Fort Griffin

LOCALITY 22



BELL COUNTY, LOCALITY 22

Sample A

Soft clay-marl washed to a small concentrate composed of large echinoid fragments and shell fragments, forams abundant.

Haplophragmium taylorense	common
Tritaxia sp.	common
Textularids	common
Gaudryina austinana	common
Lenticulina munsterina	common
Kyphopyxa christneri	rare
Anomalina cf taylorensis	frequent
Pelagics	abundant

Sample B

Same type material as previous with addition of:

Loxostomum sp.	common
Ventilabrella sp.	frequent

Sample C

Similar to previous samples but all of the concentrate passes through an 80 mesh screen and the fauna, which is almost entirely pelagic, is dwarfed.

HARTRICK'S BLUFF, LOCALITY 21

Sample A

Somewhat indurated chalky marl washed to about 20% original.

Biotite abundant in this material.

Pelagics	abundant
Citharina texana	frequent
Kyphopyxa christneri	frequent
Marginulina austinana	frequent
Palmula suturalis	frequent
Nodosaria affinis	frequent
Lenticulina munsteri	frequent
Textularids	frequent
Anomalinids	frequent

Sample B

Same as previous.

Sample C

Same as previous.

Sample D

Same as previous but with addition of:

Planulina taylorensis	abundant
Gaudryina austinana	abundant
Frondicularia lanceola	rare
Frondicularia sp.	rare
Textularids	common
Anomalinids	common

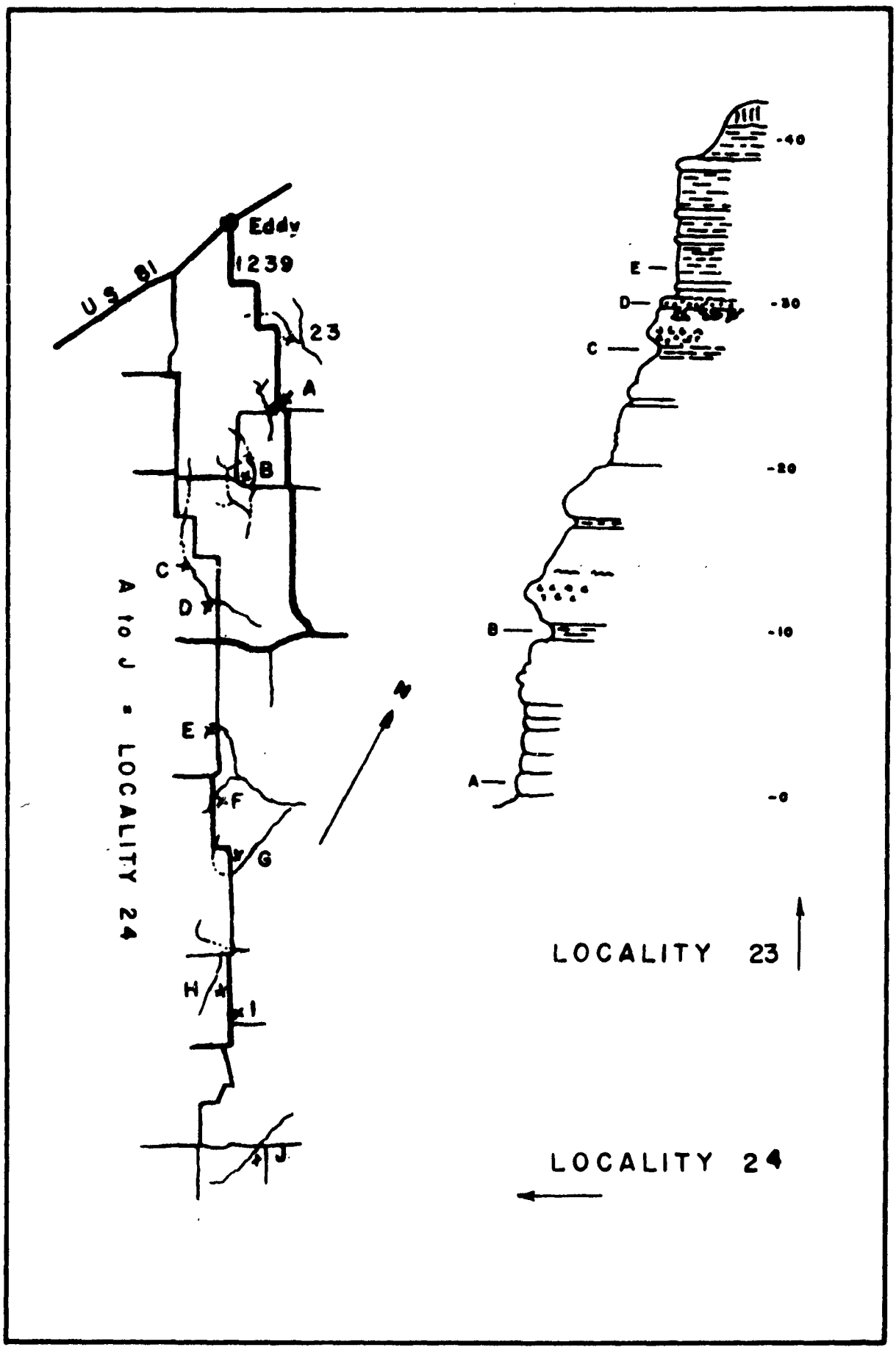
Sample E, Ft. Griffin

An unctious marl washed to about 20% of original. Only about 5% of the concentrate is larger than 40 mesh and fauna is sparse and mainly pelagic, most of the concentrate is secondary calcite.

Same species present as in previous samples but fewer in number.

LOCALITY 21-A

Samples collected at Locality 21-A were inconclusive and perhaps not properly oriented so are not listed here.


Eddy
1239
US 81
23
A
B
C
D
E
F
G
H
I
J
A TO J - LOCALITY 24
-40
-30
-20
-10
-0
LOCALITY 23
LOCALITY 24

EDDY SECTION, LOCALITY 23

Sample A

Soft marl washed to a large concentrate because of cementing of shell fragments by secondary calcite and marcasite.

Planulina taylorensis	common
Kyphopyxa christneri	frequent
Citharina texana	frequent
Frondicularia sp.	frequent
Nodosaria affinia	frequent
Lenticulina munsteri	common
Textularia spp.	frequent
Pelagics	common

Sample B

Same as previous but less secondary comentation so concentrate is less bulky.

Sample C

Similar to sample A except that Citharina texana is very rare in this and the samples above this point at this locality. New species include:

Flabellammina clava	rare
Saracenaria sp.	rare
Frondicularia lanceola	rare
Palmula suturalis	rare

Sample D

Same as previous with addition of:

Haplophragmium taylorense	frequent
Robertina sp.	rare
Pelagics	abundant

Sample E

Same as previous.

FALLS COUNTY, LOCALITY 24

Sample A

Soft marl washed to a small residue, about 3% of original weight. Foraminifera very abundant and similar to that of the Taylor except for rare specimens of Citharina texana; also included are:

Planulina taylorensis	common
Kyphopyxa christneri	frequent
Haplophragmium taylorense	frequent
Textularids	frequent
Anomalinids	frequent
Pelagics	abundant

Sample B

Same as previous sample with addition of:

Ventillabrella eggeri	frequent
Dentalina spp.	frequent
Gaudryina austinana	frequent

Sample C

Same as previous samples.

Sample D

Same as previous samples but fauna more varied including:

Virgulina sp.	frequent
Bulimina sp.	frequent
Nodosaria alternata	frequent
Frondicularia inversa	frequent
Frondicularia lanceola	frequent

Sample E

Same as previous with these additions:

Massilina sp.	rare
Loxostomum sp.	frequent

No Citharina texana observed here or above sample D.

Sample F

Soft material but shell fragments, echinoid remains, and marcasite increase the otherwise small bulk of the washed residue. Fauna as in previous samples.

Samples G and H

Same as previous sample.

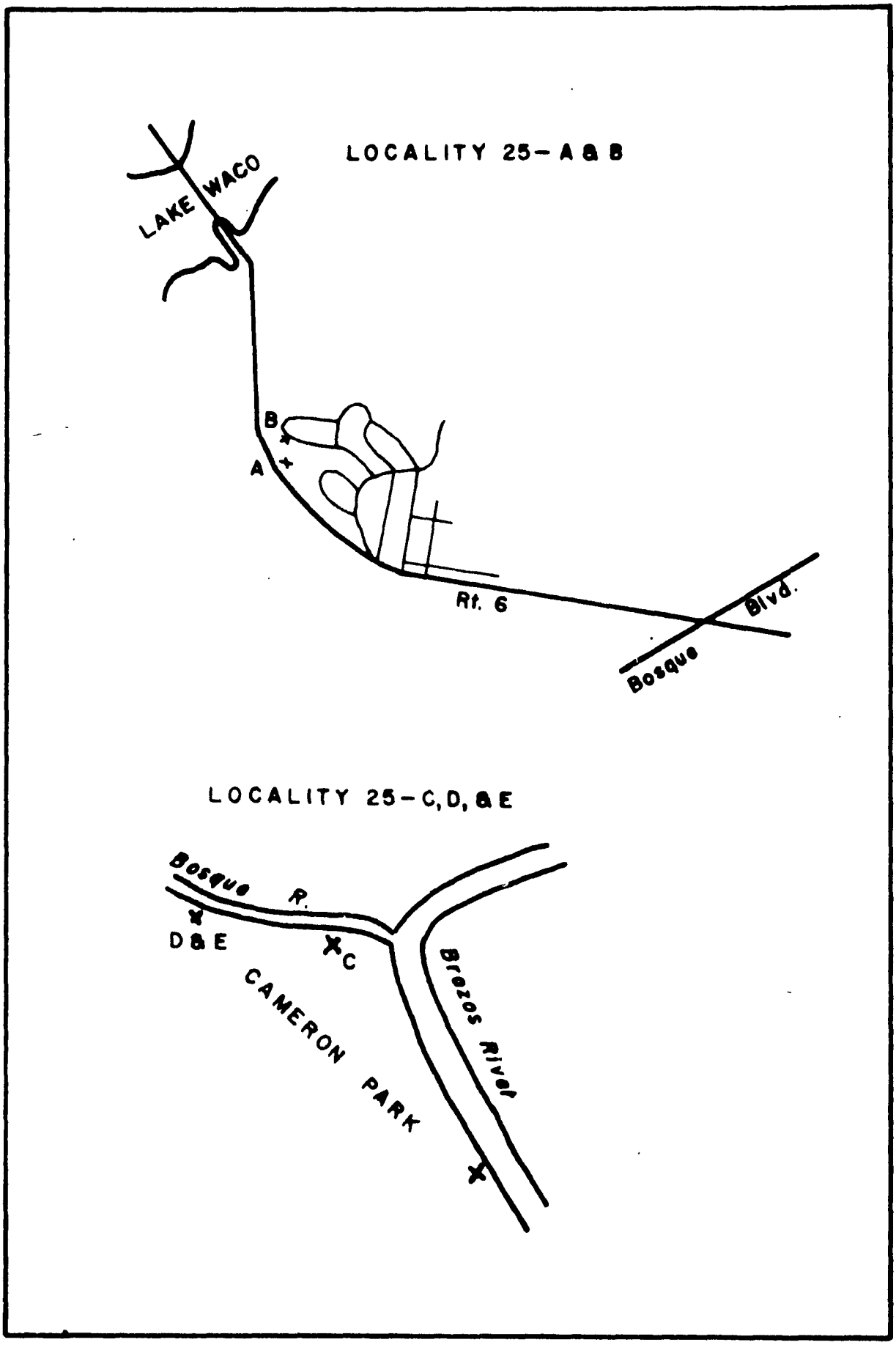
FALLS COUNTY, LOCALITY 24, continued

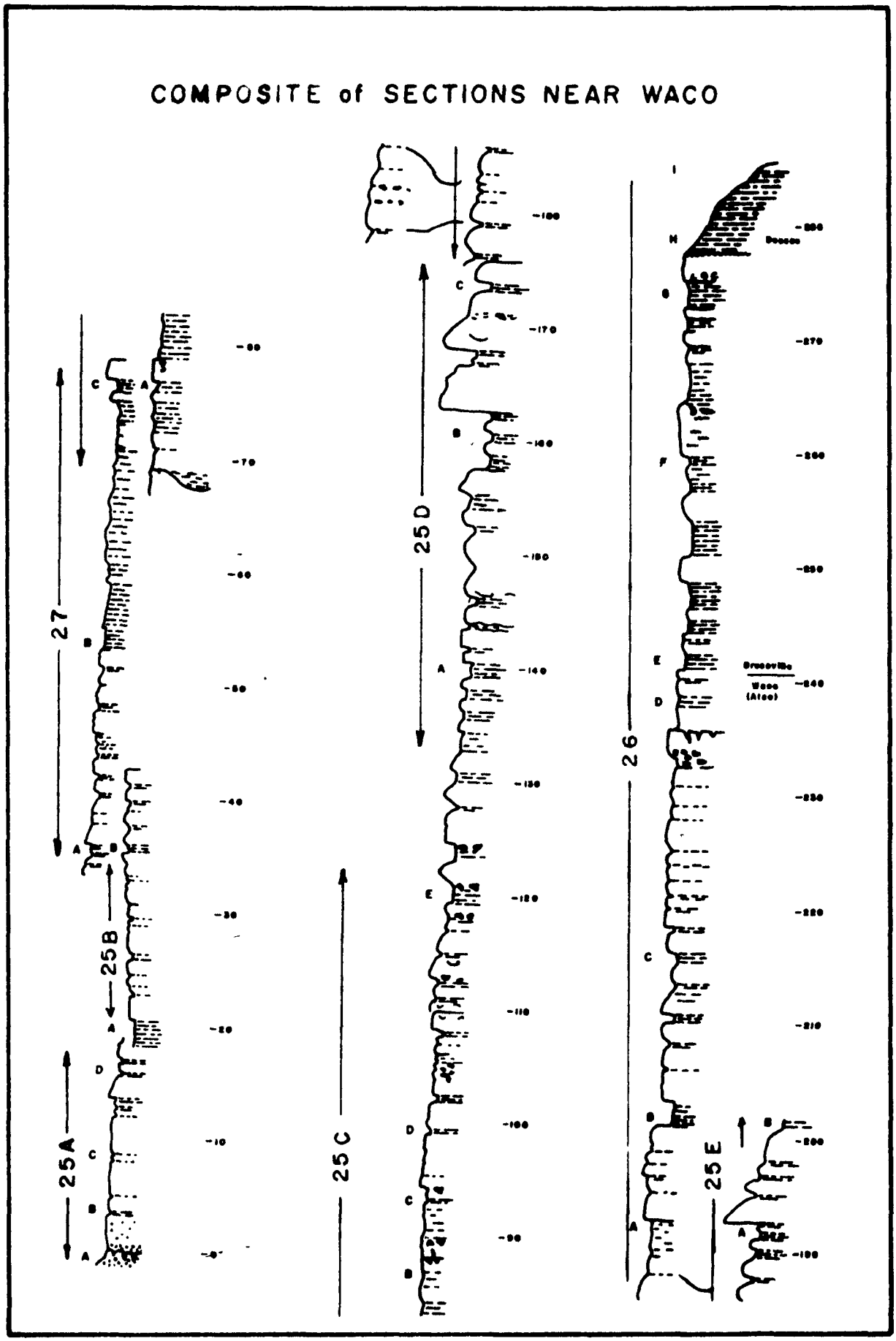
SAMPLE I

Very sandy and fine grained, fauna sparse but similar to that of previous samples; this is from the level of the Durango sd.

SAMPLE J

Same as previous except for dominant small arenaceous forms.


LOCALITY 25-A & B
LAKE WACO
B
A
Rt. 6
Bosque Blvd.
LOCALITY 25-C, D, & E
Bosque R.
D & E
C
CAMERON PARK
Brazos River


COMPOSITE of SECTIONS NEAR WACO
25A
25B
25C
25D
25E
26
27

WACO SECTION, LOCALITY 25-A

Sample A

Dark shale washed to small residue. Fauna consists of small arenaceous forms and rare pelagics.

Sample B

Chalk containing silt and marcasite washed to about 30% of original weight.

Lenticulina munsteri	common
Nodosaria affinis	frequent
Globorotalites micheliniana	rare
Frondicularia lanceola	rare
Gyroidina globosa	frequent
Anomalinids	frequent
Pelagics	abundant

Sample C

Same as previous with these additions:

Palmula suturalis	frequent
Frondicularia sp.	rare

Sample D

Same as previous samples

LOCALITY 25-B

Sample A

Same as samples at previous locality (25-A).

Sample B

Similar chalky material but fauna almost entirely pelagic.

WACO SECTION, LOCALITY 25-A

Sample A

Dark shale washed to small residue. Fauna consists of small arenaceous forms and rare pelagics.

Sample B

Chalk containing silt and marcasite washed to about 30% of original weight.

Lenticulina munsteri	common
Nodosaria affinis	frequent
Globorotalites micheliniana	rare
Frondicularia lanceola	rare
Gyroidina globosa	frequent
Anomalinids	frequent
Pelagics	abundant

Sample C

Same as previous with these additions:

Palmula suturalis	frequent
Frondicularia sp.	rare

Sample D

Same as previous samples

LOCALITY 25-B

Sample A

Same as samples at previous locality (25-A).

Sample B

Similar chalky material but fauna almost entirely pelagic.

WACO SECTION, LOCALITY 25-C

Sample A

Soft chalky marl washed to a small concentrate, fauna almost entirely pelagic.

Lenticulina munsteri	frequent
Frondicularia sp.	rare
Anomalinids	common

Sample B

Gray chalky shale with abundant marcasite and biotite washed to a rather large concentrate.

Palmula suturalis	rare
Lenticulina munsteri	rare
Frondicularis lanceola	rare
Textularids	rare
Anomalinids	abundant
Pelagics	abundant

Sample C

Gray chalky clay washed to a small concentrate with abundant Inoceramus prisms, echinoid spines, and shell fragments.

Pelagics	abundant
Anomalinids	abundant
Palmula suturalis	frequent
Frondicularia lanceola	frequent
Marginulina austinana	frequent
Gyroidina globosa	rare
Virgulina	rare

Sample D

Same as previous sample.

Sample E

Same as previous sample.

WACO SECTION, LOCALITY 25-D

Sample A

Slightly silty white marly chalk, washed to about 25% original weight.

Pelagics	abundant
Anomalinids	abundant
Citharina texana	rare
Palmula suturalis	frequent
Nodosaria affinis	frequent
Dentalina sp.	rare
Gyroidina globosa	frequent
Globorotalites	frequent

Sample B

Same as previous sample.

Sample C

Same as previous sample.

LOCALITY 25-E

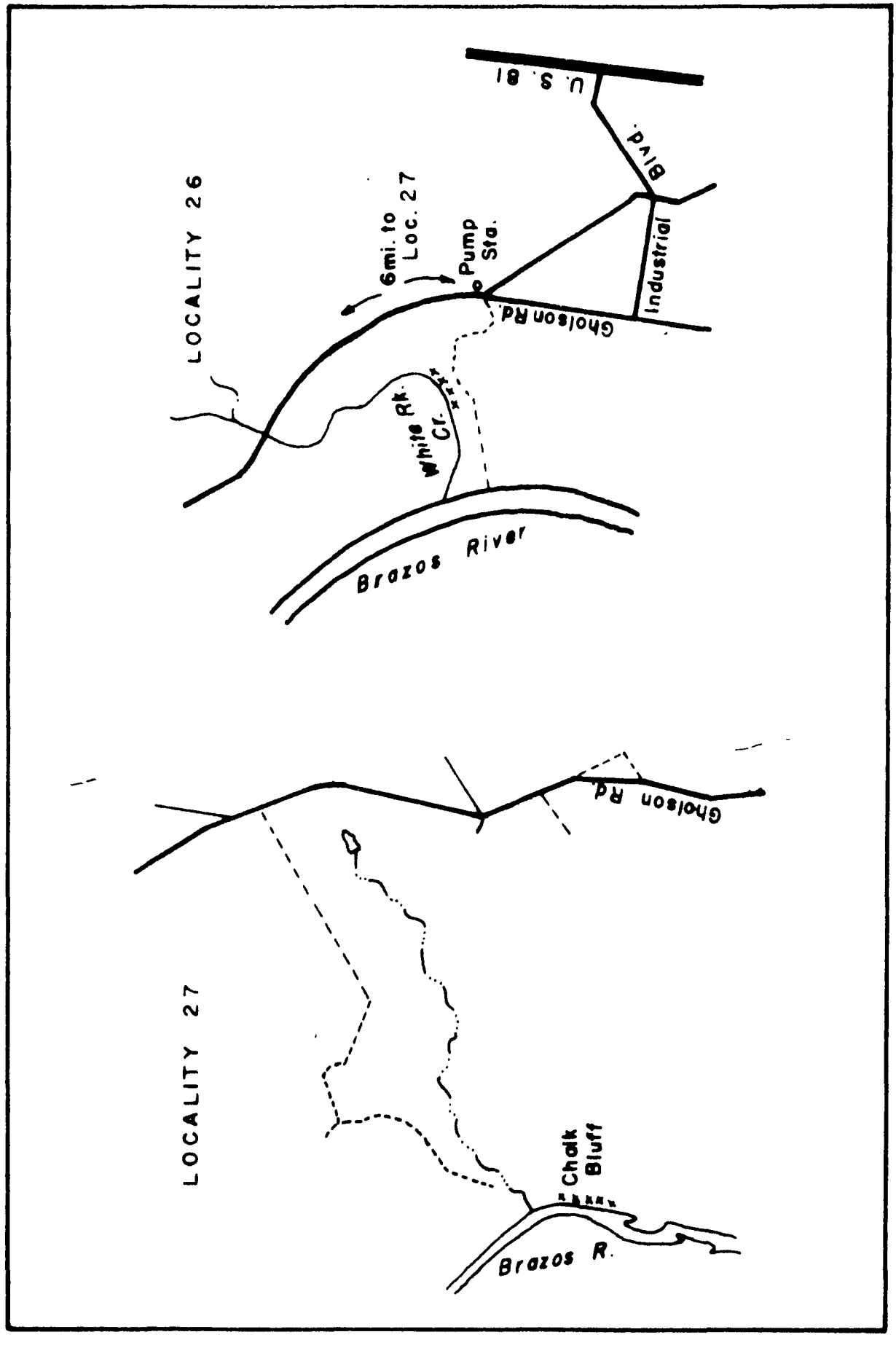
Sample A

Silty, marly chalk washed to a concentrate about 25% of original weight in which the Foraminifera are largely pelagic.

Lenticulina munsteri	rare
Citharina texana	rare
Nodosaria affinis	rare
Gaudryina austinana	rare
Textularids	frequent
Anomalinids	abundant
Pelagics	abundant

Sample B

Same as previous sample.


LOCALITY 26
6mi. to Loc. 27
Pump Sta.
U. S. 81
Blvd.
Industrial
Gholson Rd
White Rk. Cr.
Brazos River
LOCALITY 27
Gholson Rd
Chalk Bluff
Brazos R.

WHITE ROCK CREEK, LOCALITY 26

Sample A

Somewhat indurated chalky marl reduced about 50% in washing.

Citharina texana	frequent
Frondicularia sp.	frequent
Lenticulina munsteri	frequent
Nodosaria affinis	rare
Anomalinids	common
Pelagics	abundant

Sample B

Soft marly chalk reduced to 5% of original weight. Fauna abundant as in previous sample with these additions:

Dentalina spp.	frequent
Gaudryina austinana	common
Hastigerina	frequent
Globorotalites	frequent
Hastigerinella sp.	rare

Sample C

Hard chalk reduced to 30% of original weight but fauna same as in previous sample.

Sample D

Similar to previous material, fauna includes these additional species:

Flabellammina clava	rare
Haplophragmium taylorense	frequent
Marsonella oxycona	common
Palmula suturalis	frequent

Sample E

Soft chalk marl with abundant biotite, fauna same as before.

Sample F

Material same as previous sample, fauna shows marked increase in number of lagenids. Washed concentrate 12% of original.

Kyphopyxa christneri	rare
Frondicularia undulosa	rare
Lenticulina munsteri	common
Palmula suturalis	common
Citharina texana	common
Nodosaria affinis	common

LOCALITY 26, continued

Sample G

Soft marl washed to 5% of original. Fauna abundant and same as previous sample.

Sample H

Soft marl washed to 2% of original material, contains small amount of glauconite, no large forms and the following new member:

Gumbelitria sp.	abundant

Sample I

Soft material washed to a concentrate of 1% composed entirely of Foraminifera and other organic remains.

Pelagics	abundant
Gumbelitria sp.	rare
Dentalina spp.	rare
Anomalinids	abundant
Kyphopyxa christneri	rare
Gyroidina globosa	rare

CHALK BLUFF, LOCALITY 27

Sample A

Soft chalky marl washed to 14% of original

Gaudryina austinana	common
Frondicularia sp.	rare
Nodosaria affinis	rare
Lenticulina munsteri	frequent
Palmula suturalis	rare
Marginulina austinana	rare
Gyroidina globosa	rare
Anomalinids	rare
Pelagics	abundant

Sample B

Similar to above but dominated by pelagics.

Sample C

Same as sample B. Small amount of biotite also present.

VITA

Louis deAgramonte Gimbrede was born in Brooklyn, New York on October 27, 1909, the son of Louise deA. and Louis G. Gimbrede. He attended the public schools of Mount Vernon, New York and was graduated from the high school of that city in 1928. He received A. B. from Cornell University in 1939 with a major in Geology, after a lapse of several years during which he was engaged in oil production work in Texas. He was employed as micropaleontologist by Shell Oil Company, Houston, Texas until 1947 and after two years as salesman began graduate study in Geology at the University of Texas. He taught at Texas A. & M. College for three years after receiving his M. A. degree from the University of Texas. In September, 1954 he entered Louisiana State University as a candidate for the Ph. D. degree and after one year of residence found employment as Assistant Professor of Geology at the University of Southwestern Louisiana. A final term of residence at L. S. U. was completed in the Autumn of 1957. Since that time he has continued teaching at "Southwestern" where he is presently employed.

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EXAMINATION AND THESIS REPORT

Candidate: Louis deAgramonte Gimbrede

Major Field: Geology

Title of Thesis: Significant Foraminifera in the Austin Group

Approved:

H. V. Anderson
Major Professor and Chairman

Richard J. Russell
Dean of the Graduate School

EXAMINING COMMITTEE:

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Date of Examination:

December 17, 1960